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THE GLOMMEN (NORWAY) HYDRAULIC POWER PLANT.—A SECTION OF THE RACE CUT THROUGH THE SOLID ROCK.

THE HYDRAULIC POWER WORKS ON THE RIVER GLOMMEN, NORWAY.

By the English Correspondent of SCIENTIFIC AMERICAN.

ONE of the most important and largest hydraulic power works in Europe for the generation of electrical energy, both for lighting and power purposes, has recently been completed in Norway, upon the river Glommen. This waterway is the largest and most important in the country. It rises in a series of mountain lakes of small dimensions, situated at an altitude of 8,400 feet above sea level. The river follows a meandering course for about 260 miles before it discharges into the sea at Frederickstad on the Skajerak. About 80 miles from its mouth, however, it is swelled by a tributary, the river Vormen. The latter river, in the highlands of the country, before its confluence with the Glommen River, passes through Mjosen Lake, which has a surface area of 140 miles, and is on the whole very deep, the maximum depth being 1,470 feet. This lake is at an altitude of 400 feet above sea level. Beyond the confluence of the two rivers, at a level of 340 feet, is the Oeyeren Lake. This second lake is 20 miles in length, and from 2 to 3 miles in width.

These two lakes perform two valuable functions. In the first place, they arrest all the rubble and debris caught up by the higher mountain torrent reaches of the Glommen, and Vormen, so that the river upon its exodus from the second lake is practically free from obstructions. But the more important office of these lakes is that they serve to regulate the volume and temperature of the water brought down. The volume of water varies from a minimum of 3,500 cubic feet per second in the winter to 70,000 cubic feet in the average summer flood season, and in the cases of severe rainfalls to 150,000 cubic feet or more. It is, furthermore, intended to regulate the flow by the construction of a barrage at the lower end of Lake Mjosen, thereby raising the level of the water by about 13 feet. This dam would suffice to offer storage capacity for an extra 1,900,000 cubic yards of water, which would be adequate to enable a minimum dry-weather flow of 10,500 cubic feet per second, as compared with the present 3,500 cubic feet, to be maintained for about two months in the year. After the river emerges from Lake Oeyeren, it flows through a narrow channel, and drops in a succession of falls, aggregating approximately 250 feet through a course of 15 miles. There is thus produced a series of power sources, which are divided among private and government owners. One of the largest of these falls and rapids is the Kykkelsried Falls, situated approximately in the center of the group, and about 40 miles distant from the capital Christiania. These falls are the property of the Glommen Wood Pulp Company, who have been utilizing a portion of this water power for several years, for driving sawmills, grinding, and flour mills.

In 1899 the owners of the falls, in conjunction with the Schuckert Electrical Company, of Thürnberg, Bavaria, completed a scheme, whereby the entire fall of 62 feet, and an average flow of 9,000 cubic feet per second was to be utilized for the generation of electricity, and its distribution for all purposes in Christiania and the surrounding townships by overhead cables. The project was commenced in 1900, and the first section of the work was completed in September, 1903. The work presented considerable engineering difficulties, especially in connection with the construction of the embankment work. The general basis of the project comprises an impounding weir, which stretches from the left bank of the river to an island in the center of the falls, with a partially closed weir thrown across the river from the island to the right bank. An open power race or canal had to be constructed for about five-eighths of a mile. The water passes into the canal through a funnel-shaped intake. This is divided into two channels by a central pier, each aperture measuring 41 feet square, with an effective waterway ranging from 1,500 square feet to 2,200 square feet, according to the position of the inlet penstocks. The latter are of the conventional telescopic shutter type, operated by winches placed overhead, and driven by two 18 horse-power electric motors. There is a floating boom built of timber lattice work, with a close screen of planks immersed some 4 feet in the water, secured to the point of the island at one end. This boom is designed more especially to divert floating logs from the entrance to the power race, and in flood time such obstacles are directed toward the free channel over the falls. In order to arrest timbers which have become waterlogged and drift along beneath the surface of the water, it is proposed to substitute an iron tubular framing with immersed prongs to stop back such unseen obstacles, in lieu of the present wooden device.

The construction of the canal was attended with much arduous labor, as it passes partly through gneiss and partly blue glacial clay. The channel is very deep and narrow. At some places the hillside had to be blasted away to a depth of 78 feet, while the average depth of the canal is 50 feet. Altogether, 290,000 cubic feet of hard rock had to be blasted out, and 340,000 cubic yards of blue glacial clay had to be excavated. The canal has a width of 25 feet at the bottom, the sides have a slope of 1 in 10, while the bottom of the canal has a fall of 1 in 660. In those places where the waterway passed through the solid rock, owing to the hard nature of the gneiss it was possible to leave the sides of the canal undressed; but where it was cut through the treacherous clay, concrete walls had to be constructed. When the power race reaches its lower end, it opens out into a distributing basin 420 feet in length by 66 feet in width. From this receiving lake the water passes through the inlet sluices to the turbines in the power house. In order that the crown of the canal bank may not be damaged, from flooding, the masonry embankment is reduced 3.28 feet in height throughout a length of 328 feet, so as to constitute a waste weir immediately above the power house, while a by-pass is furthermore provided. For the removal of ice floes and other obstacles that may be floating in the basin, sluices are placed at the closed end. There is an effective section of the waterway in the canal at low water of 860 square feet. A needle weir, however, is to be added, and the effect of this will be to increase the effective section to 1,290 square feet. In dry weather, when the water level is reduced to that of the crest of the ground weir, the loss of head is reduced to 4¼ feet, and the speed of flow to 8.2 feet per second, the supply aggregates about 7,060 cubic feet per second, which gives, with 52½ feet head, some 30,000 horse-power. When the effective head is reduced by the high flood in the tailway, and the by-pass sluices are open, the loss of head amounts to 6½ feet with a flow in the canal of 9.8 feet per second. Under these most unfavorable conditions, in order to maintain the full capacity of the output of the station, the additional turbines will be required.

(To be continued.)

[Concluded from SUPPLEMENT No. 1532, page 24551.]

THE MAN AND THE SHIP.*

By GEORGE W. DICKIE, President of the Technical Society of the Pacific Coast.

I MUST now consider the second division of our subject—the qualities imparted to the man and to the ship by the things placed in them or given to them. This suggests the propelling power, and how long its source of supply will endure.

In naval language this is called the radius of action.

Propelling power and how long the source of its supply will last determine the radius of action, both for the man and for the ship.

While speed is not the most important thing to be considered in a battleship, yet it is of so much importance that as much space and as much weight as possible, without curtailing other and more important qualities, are devoted to propelling machinery and to coal bunkers.

The great displacement and moderately full lines of the battleship require large engine power for moderate speeds. First-class battleships are generally supplied with one horse-power for each ton of their displacement. Cruisers are generally supplied with two or more horse-power for each ton of displacement. The battleship, as a rule, however, has a larger coal capacity than the cruiser, and is therefore able to steam farther from the source of supply. The distance a battleship can steam, without receiving fresh fuel, is called her radius of action. This quality is considered, by naval men, of the first importance. If, for instance, a United States battleship and a Japanese battleship, both of the same class, were enemies, and they should both leave their home ports at the same time for a cruise on the Pacific; and should they sight each other, say 30 days thereafter, the one that had the best supply of coal left would, so far as ships went, have the best chance of victory.

Large bunker capacity and economical propelling engines are therefore of great importance in a battleship, as these are the leading features in securing a great radius of action.

The battleship may, however, leave her home port with bunkers full of good fuel, and with economical engines in first-class order; but, if the fuel is wasted in driving at full speed just to see what a wave she will make, and if forced draft is resorted to, simply to get up a little excitement on board, the discovery may be made, when the enemy is in sight, that the bunkers are empty and the propelling power useless.

In the battleship there are two kinds of coal bunkers, the reserve coal bunkers, which are situated above the protective deck—these, as a rule, would not be accessible in time of action—and the ready-service bunkers. These are on the same level with the fire rooms, and open into them, and are to be depended upon in battle. A prudent commander, in time of war, will see that the engineer keeps his ready-service bunkers well filled, so that, in case of a surprise, time will not be lost in getting coal from the reserve bunkers.

In a man, as in a man-of-war, the propelling power is of great importance, determining, as it does, his radius of action. As the propelling power is the heart of the battleship, from which she obtains life, so the man's heart is the propelling power of his life. If he be fitted with a well-balanced triple-expansion heart, and if, as he leaves his training port, the protected home harbor where he was built and fitted out, all his reserve bunkers are full of the best hand-picked fuel, and his ready-service bunkers are full of sound principles, then he need fear no enemy; but if he wastes the precious contents of his bunkers in useless excitement, ruining his boilers by forced draft, straining his engines for the sole purpose of making a big wave in society, then the enemy may find him with empty bunkers and a weathered heart.

The naval architect, in designing the battleship, has provided, as far as possible, against any failure in the propelling power, by arranging his ship to receive twin propellers, and a complete double set of engines, alike in every respect; and the power of the ship is the combined power of the two. For the best progress, therefore, they must both work together; but, if one be disabled, the other can still do its work in propelling the ship.

The all-wise Architect, who made man, saw that it would not be safe for him to be single, so he was designed for twin screws, having a complete double set of machinery, port and starboard; that is, "male and female created He them." There they stand, side by side, in the engine room, resting on the same foundation bed; and, to get the best speed out of the man, they must work together, and in the same direction. If one goes astern and the other ahead, there will be nothing but a twisting movement in the man, and racking strains that are sure to give trouble. If one goes fast and the other slow, the man will not show his best speed; but should one be disabled, the other must do its best to land the man safely in port.

There is a great element of safety in the twin-screw principle, both for men and for ships. Many a man and many a ship has managed to pull through life on the single principle; but, let anything happen with the propelling power—with the heart, as it were—and they are either among the missing, or they may be picked up at sea disabled and towed into port. Should that happen, in the case of either the man or the ship, salvage claims are likely to exceed the value of the property.

Two sets of triple-expansion engines are necessary for the battleship, in order that she may safely carry the flag as far as her fuel will last, or into battle, and hand her name down to the ages on the naval roll of honor.

Two sets of triple-expansion hearts are necessary for a complete and seaworthy man, so that he may safely meet the struggles of life, and preserve his name and honor to posterity.

Another quality, necessary both to the man and to the battleship, if they are to be serviceable, is adequate means of defense. In the man-of-war or battleship, to which I refer, the naval architect provided an armor defense of the most modern design, and required it to be constructed of the most effective material yet invented, to resist penetration by shot from an enemy.

When shipbuilders began to build iron-clad ships of war, the armor protection was carried the full length of the ship, as it was desired to make everything about her safe; but other inventors, just as skillful as the shipbuilder, were at work on the means to penetrate the protection that had been built around the ship; and, as guns became more powerful, the armor defense had to be made thicker and heavier, until the displacement (that is, the foundation) failed to carry it; and so it came to pass that the whole length of the ship could no longer be covered by armor, even when face-hardened, which would resist an armor-piercing shell from the modern gun.

So the designer of our man-of-war adopted what is known as the citadel type, the main feature of the design being that the heavy armor protection extends only over the vital parts of the ship, protecting the engines, the boilers, the big guns forming the main battery, the intricate mechanism that operates them, and the magazines. This armor is all Harveyized or face-hardened steel, which has been proved as to its ability to resist penetration, even at short range, and by the most powerful guns.

The citadel of heavy armor is about 200 feet in length, and the armor of the lower part, or side belt, is 18 inches thick. The armor of the bulkheads, forming a parabolic curve at each end, is 14 inches thick. At each end of this structure, and rising directly above the bulkheads, is a circular redoubt or barbette, with walls 14 inches thick and 12 feet high, protecting the base of the revolving turrets, and the intricate hydraulic machinery that operates them. Above these redoubts rise the upper portions of the great revolving turrets, 35 feet in diameter, each weighing 400 tons, and having armor 12 inches thick.

Above the heavy belt armor I have described, the sides are plated with 5-inch steel armor, forming a casemate for the protection of the crew and upper works against the attack of rapid-firing secondary batteries, so fatal to unprotected quarters.

Above this upper belt of armor rises the superstructure, with armored sponsons for four 6-inch guns; and, at each corner, still higher, so as to fire over the roofs of the great turrets, are mounted the four armored turrets for the 8-inch guns which proved so effective in the destruction of the Spanish fleet off Santiago.

This man-of-war of ours carries more and heavier armor than any other battleship in the world having the same displacement or foundation, and foreign naval designers have wondered how we have managed to get so much on our foundation of 10,400 tons.

In the ends of the vessel, beyond the armored citadel, there are numerous storerooms, where wet and dry provisions, all clothing and equipage, besides the personal effects of officers and crew, are carried. The rooms where the officers live, and the quarters for the crew, are also outside the armored citadel.

A man, like our man-of-war, must also have, if he is to be a true, safe, and noble man, an armor-protected citadel, on which his safety will depend in time of battle. His storehouses, into which he packs his earthly belongings in ordinary times, and while cruising peacefully on the sea of life, are very necessary and convenient for his comfort in and enjoyment of life. But no man has displacement enough to carry armor protection for these. If he sets himself to protect these things, then, in time of battle, he must leave unprotected the most vital things of his life.

The true man must therefore have a citadel, within which he places his propelling power—that is, his heart; the boilers, which furnish his power of will to

* Read before the Association of Engineering Societies, March 3, 1905.

do the right thing and keep in the right course; his magazines of truth—those things which he must stand by—the shot and shell with which he fights every power of evil that seeks his destruction. Around these vital elements of his being, he must dispose whatever armor the great Architect has furnished him with, so that, in the day of battle, when the final test is made of his power to endure the onset of the adversary, and to stand fast, no matter what may happen in his armored citadel, the great principles which govern his life may be carried through the fight, and nothing given up to the enemy but what can be readily replaced when the battle is over.

In the battleship, even life itself is not the first thing to be considered. The life of the crew is protected by a casemate of 5-inch armor, while the vitals of the ship are protected by 12 inches of armor.

So, with a man, there should be some things that are more than life. There are the great truths that he believes and holds more sacred than life itself, and around these he will concentrate all his powers of resistance, knowing that, if he meets death and these live on, the victory is his. So, whatever power we have to resist the fire, let it be concentrated around the most precious and enduring things.

But, for a man and for a ship which have to fight their way through life, there must be means of offense as well as of defense. Hence, for the ship we have been considering, the naval architect provided a powerful battery, of both great and small guns. He also designed magazines and shell rooms, properly protected by armor, to carry a great store of ammunition, with ample means for handling both the guns and the ammunition for serving them properly.

The great battleship, which I have had in mind throughout this lecture, has a main battery consisting of four 13-inch breech-loading rifled guns, mounted in two revolving turrets, one at each end of the armored citadel. These turrets are worked by hydraulic machinery within the armored redoubt. There are eight 8-inch breech-loading rifled guns, mounted in four revolving turrets, protected by 8-inch armor. These turrets are operated by steam machinery, placed down under the belt armor line.

There are four 6-inch guns mounted in the superstructure, and protected by 5-inch armored sponsons. These guns are trained by hand. This constitutes the main battery, which is more powerful than that carried by any other warship on the same displacement or foundation.

The secondary battery consists of twenty 6-pounder rapid-fire guns, mounted all around the upper line of the superstructure, their position being protected by the hammock berthing; that is, a line of double walls of plate steel, between which the sailors' hammocks are packed, forming a protection against the fire of small guns.

It was for the purpose of carrying this great battery into action, and using it effectively, that this great ship was designed. All her other qualities have been devised and worked into the general design for this purpose. That battery and the armor that protects it were designed not for the wanton destruction of some poor, weak antagonist that could not return blow for blow. It was all devised by the designer to protect the honor of that flag that waves so proudly above it, and to stand for defense of the right. For this purpose the naval architect prepared his plans, balancing one force against another, working harmony out of their contending elements. The engineer, for this purpose, installed, in the center of this great structure, his mighty engines for propulsion, the beating heart of the whole. For this the ordnance expert conceived the wonderful and intricate mechanism to handle ammunition, and to operate guns and their mounts. For this purpose the electrician planned, and placed far down in the bowels of this mighty structure, the electric generators that supply the subtile fluid, the nervous system of this great machine, that gives light to the dark places, and motion to many wonderful contrivances. By it the eye of the projector is illuminated and its movements controlled, enabling the commander to pierce the gloom of the blackest night.

The optician not only planned the instruments whereby the navigator can tell where his ship is, but a range finder also, whereby the position of the enemy can be determined.

All this and very much more are brought into play, in order that the battery and its protecting armor may be brought successfully into action, and that the cause it represents may be triumphant.

In a man, as in a man-of-war, all his qualities must be trained for the purpose of enabling him to carry his battery successfully into the battle of life. Many contending forces and antagonistic powers have to be brought to work together for the end in view.

In all our planning for a complete and efficient manhood, we must, like the naval architect, set the forces in couples against each other, taking care that the righting forces will more than balance the heeling forces, training the body—that is, our hull—to properly carry the mental battery with which it is equipped. Sacrifices must be made of many cherished possessions, or of acquired habits, to make room for more important things that cannot be left out if our battery is to be efficient in time of battle.

A man-of-war is a complicated combination of compromises, and so is a man. We can carry no more than our displacement represents, and we shall not be able to realize, in action, all that we had planned, and sacrificed for, to obtain.

But we can so carry our battery—that is, the mental caliber with which the great Architect of our being has endowed us—into the battle of life, that, however the battle may go with us, whether it be victory or defeat, it shall not be disgrace.

Having thus noticed the material elements in the man and in the ship, I may be permitted, in closing, to devote a few words to the crew complement of the ship, and to the personnel of the man.

In this lecture, I have endeavored to compare the material elements entering into the character of the man, and into the structure of the ship. We have examined the foundation supporting each; the stability due to dimensions and to the height of M above G; the steadiness, due to form combined with the qualities that produce stability; the structural strength; the radius of action; the armor and armament; and we have endeavored to show how the qualities that go to make a good ship are like those that go to make a good man.

But neither a good man nor a good ship will accomplish much, unless handled by an intelligent and faithful crew that knows the power and capacity of the mechanism it is to operate. The crew of a gunboat is not expected to accomplish, with the means at its disposal, what is expected from the crew of a battleship; nor is the will power of the man who has a small displacement, with little protecting armor, and a light battery, expected to accomplish as great things as the man of strong will power—a man of great character behind strong armor, with an intellect of great caliber and magazines full of rich experience.

Yet, whatever be the size or power of either man or ship, each is expected to accomplish the purpose for which he or it was built and equipped; and this they can do only if the crew complement of the man-of-war and the personnel of the man are of the right kind.

If our man-of-war is not commanded by a brave, wise, and prudent captain, who knows what kind of ship he commands, her power and capacity, with all its limitations, her best trim and best speed, what class of enemy she can meet and battle with, and how the battle must be fought if the victory is to be gained; if the executive officer has not an eye to the efficiency of all the working force of the ship, testing everything often, and in all weathers, taking nothing for granted, but by personal inspection keeping, at all times, familiar with every detail, so that the hour of struggle will find everything in working order; if the navigator fails in his duty to find out every day the true position of the vessel, the position of all dangers, the force and direction of all currents; if he does not keep his course worked out ahead and plotted on the chart for guidance; if the watch officers do not keep their eyes open for every danger that surrounds them, that no lurking torpedo boat gets near enough to discharge its deadly weapon, or enemy gets within range without the captain's knowledge; if the engineers fail to keep in perfect order all the machinery under their care, so that any sudden call for the best that such machinery can do can be responded to; if the ordnance officer has neglected to see that all the mechanism for training, elevating, and controlling the guns is in good order, that the ammunition hoists are operative, that his telescope sights, range finders, battle-order transmitters, and all other things on which so much depends in action, are all as they ought to be; if the doctor neglects the health of the crew, and if, in consequence, they become inefficient—then, in the hour of battle, our well-planned, strongly built, magnificently equipped battleship will be found wanting; all the talent expended in its production will be lost, and the flag that it carries disgraced, because the power that willed to do failed.

As it is with the man-of-war, so it is with the man. If the will in command be weak, cowardly, or vacillating; if it either fails to order aright, or orders at the wrong time; if the executive force that carries the will power into execution cannot be depended upon when he knows the right thing to do; if the navigator's skill is so defective that the man never knows where he is, or what dangers surround him, or from which side the enemy is likely to attack him; if he goes through life in an aimless sort of way, with no watch on deck to keep him warned of danger; if his machinery is neglected; if his affections are all adrift, with no center for his heart to work upon; if he cannot respond to a call for a supreme effort in time of battle; if his ordnance, with all its delicate mechanism for training his best thoughts against the powers of evil, is inoperative through want of practice; if he has taken no care of his health; if he has contracted habits destructive of discipline and all proper management of himself—then, no matter how well he was planned and equipped, his record in life will be a failure.

The great Architect planned and equipped this wonderful organism of ours, with its vast possibilities, placing us in command, having the freedom of our own wills, and launched us out on the sea of life, amid dangers and storms, with enemies on all sides, and yet with powers of offense and defense sufficient to carry us triumphantly through every struggle. Let us but be faithful to our high calling, and see to it that whatever power we possess shall be kept in good working order and ready for action; that none of it shall be squandered in idleness and self-gratification; that, be our power or influence great or small, it shall be expended for the purpose of setting wrong things right and making crooked things straight and sad hearts happy.

Only this kind of use, made of our lives, will give us satisfaction and please the great Architect who planned us.

New Sacchariferous Plant.—The German technical journals describe a new plant discovered in South America containing a large proportion of sugary matter. It belongs to the species denominated in German Kunigundenkraut (*Eupatorium cannabinum*) and attains a height of 20 to 30 centimeters. The chemist Bertoni regards its industrial value as of prime importance. Tests are said to have shown that it contains from twenty to thirty times as much saccharine matter as sugar cane or the beet. The name *Eupatorium rebandium* has been proposed for this marvelous plant.

THE LAW OF DEODAND.*

How many practical railroad men know anything about the law of deodand, and what the term means? Probably very few indeed, and they are certainly not to be blamed if they do not, for it was an ancient English law, which has been obsolete now for a hundred years and more, and would have been completely forgotten long since were its name not preserved in the history of the ancient common law.

By the early English law there were certain sources of the revenue of the crown provided for, as the right to the royal fish cast ashore (whale and sturgeon), to shipwrecks, treasure-trove, estrays, and so on; besides forfeitures for certain crimes and offenses. To these were added the forfeiture of misfortune, or deodand, which is thus described by Blackstone, the well-known commentator upon the English law:

"By this is meant whatever personal chattel is the immediate occasion of the death of any reasonable creature, which is forfeited to the king, to be applied to pious uses, and distributed in alms by his high almoner. It seems to have been originally designed as an agency operating as 'an expiation for the souls of such as were snatched away by sudden death, and for that purpose ought properly to have been given to the . . . church, in the same manner as the apparel of a stranger who was found dead, was applied to' securing prayers for the repose of his soul.

"If a horse or ox or other animal of his own motion kill, as well an infant as an adult, or if a cart run over him, they shall in either case be forfeited as deodands. Whenever the thing is in motion, not only that part which immediately gives the wound (as the wheel which runs over the body), but all things which move with it, and help to make the wound more dangerous, as the cart and loading which increase the pressure of the wheel, are forfeited.

"No deodands are due for accidental happening upon the high sea, that being out of the jurisdiction of the common law, but if a man fall from a boat or ship in fresh water and is drowned, it has been said that the vessel and cargo are in strictness of law a deodand."

The average railway company is quite ready to maintain that the damages which are liable to result from the accidental destruction of human life are severe and excessive, and perhaps it is true that they are in many cases, but what would be the position of the railway if the law of deodand was still in existence, as it once was? In that case, if a person should be destroyed by a railroad train, engine, cars and contents, all would be liable to be forfeited, as the measure of damage of the injury; not only the carriage and its wheels which caused the injury, but also everything, to the last of the train and cargo which went to increase the irresistible, onrushing force of the crushing steel, must all be given up as expiation for same, perhaps hundreds of thousands of dollars' worth of property, in case of valuably loaded freights.

How long would the railroad companies be in existence if such a law prevailed to-day? But fortunately it does not, and never will again, though in early days this was one of the giant obstacles which the railway had to face in England, in the first years of its history.

And yet in the face of the severity of the principles of the law of deodand, it can not but be matter of surprise how moderate were the judgments of the coroners' juries in such cases as it was applied in connection with accidents.

In November, 1838, a locomotive on the Manchester and Liverpool Railroad exploded, and its engineer and fireman were both killed in consequence, yet the deodand assessed on the engine by the coroner's jury sitting upon the case, as a forfeiture, was only twenty pounds for both men. But on the other hand, only one year later, one of their locomotives struck and killed a man and horse at a crossing, and in this case the deodand was set at fourteen hundred pounds, the full value of the engine which had done the damage.

In these modern times the measure of damages in all accident cases is arrived at in a much different fashion, as the reader well knows, the earning capacity of the individual injured but not killed outright being the circumstance, rather than the worth of the carriage, or thing which is the source of the pecuniary harm, which determines the amount of the pecuniary forfeit to be paid.

In still another most important particular, too, the present day theory of establishing damages differs materially from the one which existed under the ancient law of deodand, and that is the amount of negligence or wanton carelessness, if any, of which the injured was guilty, and the extent to which he contributed to the inevitable happening of the accident. This is a most material and vital circumstance, and the wonder is that the early law did not give it more recognition. In cases of deodand no such principle was taken into consideration. The injustice of such a course is apparent. Why should punishment be meted out to one in no way responsible for the happening of an accident, lamentable though it may be? If one per-

* By R. B. Buckham, of the Massachusetts Bar, in Locomotive Firemen's Magazine.

sist in walking on the tracks of the railroad, where the public have no right of way, if he be injured it is entirely his own fault, and no one else can in fairness be held to blame. For this reason also, it is well that the law of deodand is now obsolete. On the whole, the railroad companies should be gratified with the thought that the damages which fall upon them as the result of accidents are no worse than they are.

THE MASSIE WIRELESS TELEGRAPH SYSTEM.*

By A. Frederick Collins.

That there is still room for improvement in apparatus utilized in wireless telegraphy is plainly evinced by the constant stream of patents granted to inventors in this class. Some of these are designed to cover entire systems, others are for specific parts, but all are devised for the purpose of furthering the efficiency of the equipment and economy of the art.

At the present time there are two distinct types of transmitters in general use, namely, *a*, the induction coil, which utilizes a direct current, and converts this into an alternating current by means of an interrupter, and *b*, the transformer, using as its energizing medium a simple alternating current. Both of these types are built in many forms, but in any event the fundamental principle underlying their operation is identical in so far as the conversion of current electricity into electric waves is concerned, in that they both produce this result through the disruptive discharge.

In the matter of receptors, there are likewise two general classes that have found favor according to the requirements of the case, the first employing a detector having a wide range of resistivity in combination

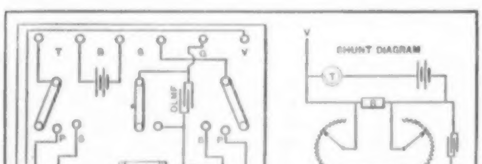


Fig. 1.—DIAGRAM OF THE MASSIE SYSTEM.

with a relay and Morse register, and the second a detector of limited resistance variability, and used in connection with a telephone receiver. The former is in accordance with European, and the latter with American practice; but though the Marconi, the telefunken (Slaby-Arco-Braun), etc., systems advocate the filings coherer and Morse register type, they also furnish detectors and indicators of the telephone type, while the Fessenden and De Forrest companies supply those of the latter-named type only.

Both the above-enumerated types have their advantages and disadvantages, to wit, the coherer, relay, and Morse register will not pick up, translate, and indicate the telegraphic code at as great a distance as the auto detector and telephone, while the latter requires the constant attention of an operator, for its indications are only feebly audible. To combine the advantages of both these types, and eliminate their individual untoward features, has been the aim of Walter W. Massie, a young inventor of Providence, R. I.

In order to achieve this much-to-be-desired result,

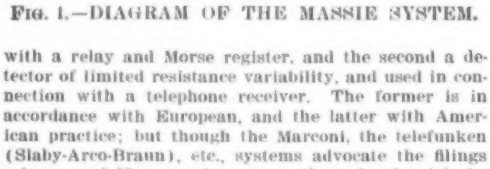


Fig. 2.—MASSIE MICROPHONE DETECTOR AND RECEIVER.

Massie employs an auto-detector for the reception of messages in combination with a new form of magnetic coherer for the purpose of signaling. Simplicity has been obtained by so designing the instruments that they require practically no adjustment after they are once assembled, no care or renewal of parts. Efficiency is guaranteed by placing in the hands of the operator a system that is limited in speed only by the proficiency of the operator, while all the circuits, both internal and external, are controlled by a single mechanism.

Just now a great deal of attention is being given to the development of the electrolytic wave detector, both

Fig. 3.—MASSIE SWITCHING DEVICE.

at home and abroad, and it is in truth an instrument of great sensitiveness. The new Massie detector compares not only very favorably with it in long-distance work under trying circumstances, but it possesses the very decided advantage of retaining its stability, which the other does not.

The Massie detector is an auto-coherer of the steel and carbon type, and owing to its remarkable character of constancy, it will work through all kinds of interference without failure, and at the same time it will receive over greater distances than any other, for reasons which will presently be apparent. Fig. 1, *A*, is a diagram of the *oscillophone*, as Massie calls his detector, and its auxiliary apparatus and circuits, while Fig. 1, *B*, is a diagram of the shunt, and Fig. 1, *C*, is a diagram of the potential circuits.

The oscillophone is constructed in such a manner that its resistance can be used as a shunt or as a regulator of the potential across the detector; the shunt method is used when receiving at close range, the potential method for long distances. As may be observed by referring to Fig. 2, the terminals of the oscillophone are made of flat pieces of carbon, specially prepared for the purpose and ground to a knife edge;

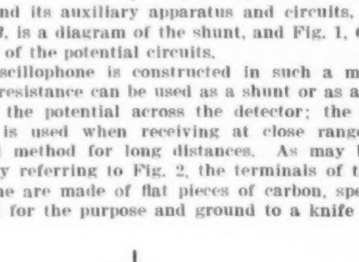


Fig. 4.—MASSIE ELECTRIC WAVE DETECTOR.

the bridging element is formed of a highly-tempered steel wire of proper size and weight.

The bridging wire is held in place by a permanent steel magnet, which not only prevents rolling and other movements that affect the indicators, but causes the wire to maintain a certain definite pressure on the carbons, which insures in turn readings that are absolutely accurate. The normal resistance of the oscillophone is about 43,000 ohms, this dropping after the passage of the electric oscillations to approximately 700 ohms. The telephone receivers used in connection with this detector have their magnets wound to 1,500 ohms.

One side of the potentiometer or variable resistance is wound in 10-ohm steps, while the opposite arm has fifteen coils wound to 150 ohms each, so that a total of 1,650 ohms may be thrown in if necessary. The connections are so arranged that the battery can be treated without removing them from the box in which they are inclosed. A condenser having a capacity of 0.01 microfarad is also contained within the case forming the base of the oscillophone, and is connected in series with the ground terminal of the resonator or receiving wire; it is used in connection with an induction coil, so that the system may be properly tuned.

The bell alarm attachment, which is an especial feature in this receptor, is in a circuit separate and distinct from the oscillophone set, the latter being used only for the reception and indication of the incoming messages. The connections between the aerial and earth wires, the transmitter, the bell alarm, and the oscillophone are made through an ingenious controlling switch. This is shown in Fig. 3, and all the circuits are thrown in and out of action by the simple manipulation of the handle at the right of the device.

When the induction coil of the transmitter is in operation, the receiving circuits of both the bell alarm and oscillophone are opened; and when these are short-circuited, the transmitting energy is cut off. This enables the operator to change from the sending to the receiving instruments quicker, with less trouble and more certainty than by the use of spring jacks, double-throw switches, or other forms of devices usually supplied with wireless telegraph outfits.

The detector used in the bell-ringing attachment is different from that used in the oscillophone, in that it is a filings coherer, yet it is pointed out by Massie that it is unlike the ordinary coherer, i. e., where the filings are placed between horizontal conductor plugs, the oscillatory current has to overcome the force of gravity on the filings before it can cohere them. The Massie coherer involves new principles as well as merely a new form; it is shown diagrammatically in Fig. 4; the complete alarm device is indicated in the photograph, Fig. 5, and in the lower left-hand corner the little vertical coherer may be seen.

Referring again to Fig. 4, the principles upon which the coherer is based may be had at a glance. A metal bridge, *b*, constitutes one terminal of the coherer, and also serves to support the cup, *c*, the latter having a silver lining, *l*; this contains a layer of non-magnetic filings preferably of silver, *s*; an adjustable magnetized needle, *n*, joins the other and opposite conductor terminal, its magnetic energy serving to sustain a layer of magnetizable filings, *i*, of soft Norway iron.

The magnetized iron filings being superposed on the silver filings form an imperfect electrical contact having an infinitely thin insulating film of air between them. Since the filings of these two different metals

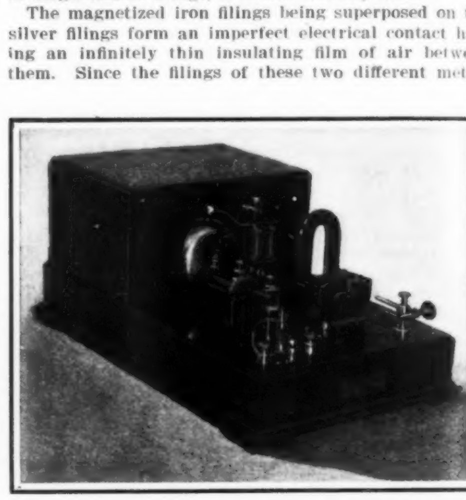


Fig. 5.—COHERER AND CALL BELL.

are oppositely disposed and in a line at right angles to the surface of the earth, the effect of cohesion produced by the oscillatory current and gravitational force is exerted in the same direction.

This being a fact, the electric energy required to break down the air gaps is reduced to a minimum; again, the total mass of filings is not necessarily cohered, as the oscillatory current takes the path of the least resistance, which is radially across the surface to the sides of the silver cup. The tapper, *t*, decoheres the filings by striking gently on the brass bridge, *b*; the electro-mechanical portions are a little different than in the usual types, the magnets of a sounder being utilized to furnish the means for making and breaking the circuit automatically.

This form of coherer is not only more durable, but more reliable than other forms. Its normal resistance may be arbitrarily varied between wide limits by the quantity of filings used; when cohered, its resistance is very low—from 30 to 50 ohms—rendering the use of

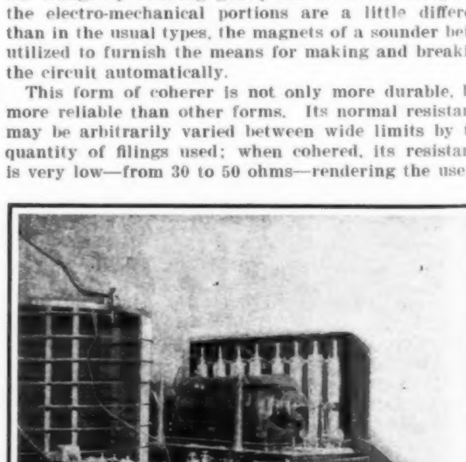


Fig. 6.—MASSIE WIRELESS TELEGRAPH STATION.

a very inexpensive relay possible and yet obtaining quite satisfactory results. The coherer responds to any signals that can be read with an ordinary detector of almost any form, and in conjunction with the alarm bell furnishes a most valuable adjunct to the system.

The transmitter shown in Fig. 6, comprising the usual inductance coil, special key, inductance coils, and cylindrical condensers for tuning the oscillation circuits, is used in the Massie apparatus for distances up to 100 miles, but for covering greater ranges a trans-

* Specially prepared for the Scientific American Supplement.

former operating on a 110-volt 60-cycle single-phase current is used.

The above statements are based on the actual performance of the Massie system in every-day practice. It is used at the Block Island and Point Judith stations by the Providence Journal, and at the Wilson Point station, which controls Long Island Sound, in working with the boats of the New York, New Haven and Hartford Railroad. The latter company adopted this system a year ago, and has operated it since that time with the most satisfactory results.

The instruments have worked continuously since their installation through all kinds of weather and atmospheric conditions. Lightning discharges produce only a slight click in the oscillophone, and do not affect or throw it out of adjustment to the slightest degree. During the preceding summer, boats and stations have successfully worked with thunder storms directly between them. Before erecting a permanent station at Wilson's Point, Mr. Massie tested the location by fitting up a temporary equipment.

The location is surrounded by a chain of islands, which it was thought might interfere to some extent with the operation of a station at that point. To test the conditions, a switchman's shanty was pressed into service as an instrument room, and a 50-foot pole was erected to support the two vertical wires forming the aerial. Grounds were obtained by using two 3-foot lengths of railroad iron to which were attached 50-foot lengths of No. 6 bare copper wire thrown out into the water. Dry cells were utilized to provide the initial energy, and with this crude arrangement a remarkably long distance was covered when the temporary equipment was converted into a permanent station.

The new stations have 180-foot masts, and instead of dry cells the coils are energized by 36 Edison-Lalande cells of 600 ampere-hour capacity, the writer having been informed by Mr. Massie that these have rendered most excellent service and given complete satisfaction; the batteries require renewal about twice a year. Boat installations obtain their power from the lighting circuits, the voltage being reduced by a suitable resistance.

Opportunity is provided by the Block Island station to test the sensitiveness of the oscillophone receptor, as the west-bound ocean liners are heard from the time they first get into touch with the Nantucket Shoal lightship. This is 90 miles east of Block Island; and assuming that the ships are working over a distance of only 60 miles, this makes a total of 150 miles the ether waves have to travel before they are received by the sensitive oscillophone.

DECORATIVE INSULATING BEADS FOR UNINSULATED ELECTRIC LIGHT WIRES.

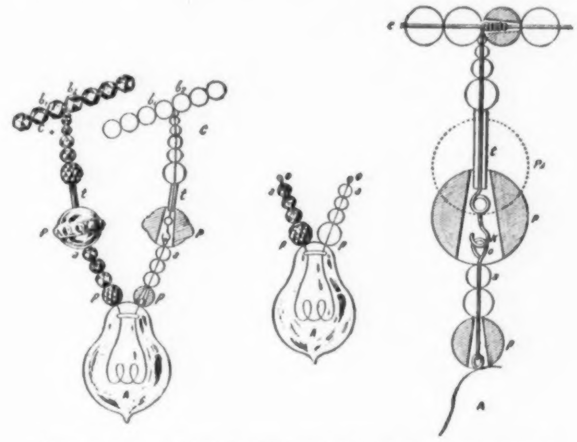
It is a recognized fact that the incandescent electric lamp lends itself better than does gas to the lighting of apartments, and readily adapts itself to the style of chandeliers and fittings, through the use of decorative glass-work under which the bulbs are concealed.

But, on the contrary, in the majority of cities of small size, gas, for an equal amount of light, costs less than electricity. The objection is made to electricity, too, that it has done away with gas pipes only to replace them with moldings that have as disagreeable an appearance as the pipes, and the more so in that, for the easy inspection of the wiring, it is still preferable to leave the moldings conspicuous.

At the present price, electricity is therefore a light for the rich. Now, when a private individual adopts this kind of lighting it is rarely the case that he does not spend more than he wishes to in order that it may be more efficient. This makes a small increase in the capital locked up, while the cost of lighting, which must be paid every month, represents a much larger capital than the first and affects a person's income. So it is no wonder that house owners are desirous of reducing the expense of electricity to a minimum. We have nevertheless heard the remark made by well-informed persons that electricity is costly because people do not know how to use it, and that even with the ordinary lamps, it is possible, by knowing how to arrange them properly, to obtain a much superior production of light and, at the same time, to effect a reduction in the expense.

Electric beads have been devised for the double purpose of abolishing moldings through the use of the wires themselves as supports for *motifs* that complete the decoration of a room, and for distributing the light better through a rational distribution of it. Electric beads, upon the whole, constitute an entirely new method of electric lighting of great simplicity, and that consists in the use of cut-glass ornaments for covering the conductors, insulating them, and leaving them all the flexibility necessary for lending themselves to the fancy of the decorator.

The system is as follows: The electric conductors employed are naked wires of copper, and consequently inexpensive, upon which are strung beads of cut and polished glass of which the size and shape are variable, but which, from the view point of fixation, are of two types—those with a cylindrical hole, and those with a conical one. The former insulate the conductors in a continuous manner, while the second cover and insulate the joints.



Figs. 2, 3, 4.—DIAGRAMS SHOWING THE METHOD OF MOUNTING THE ELECTRIC BEADS.

The first three figures give an accurate idea of the arrangements adopted. It is preferable, as is well known, to mount the lamps in derivation, and hence the use of the two conductors, $C+$ and $C-$, covered with cylindrical-holed beads, b_1, replaced at the joints by similar beads, b_2, with conical holes. In order to connect a lamp, the coupling wires are likewise covered with beads, and, near their free extremity, is fixed a tube, *t*, upon which a ball, *p*, may be slid.

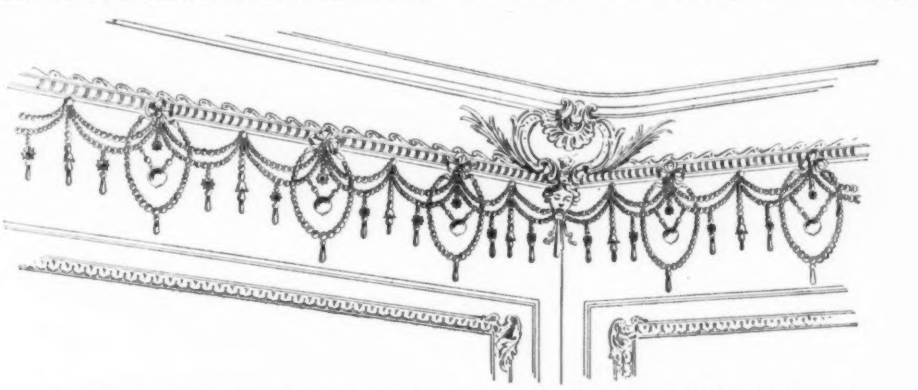
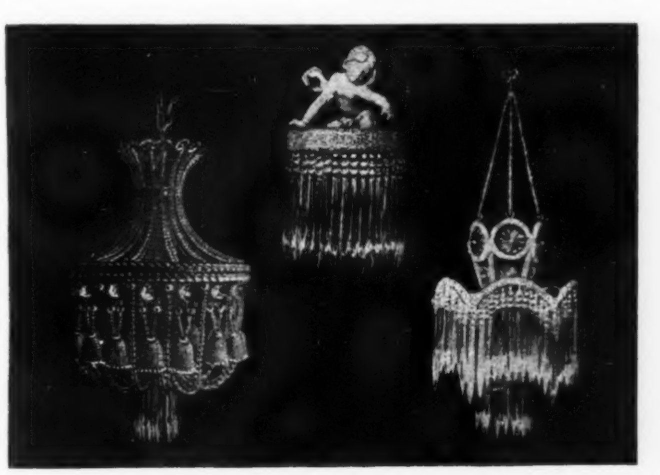


Fig. 1.—FRIEZE IN THE STYLE OF LOUIS XVI. FORMED OF ELECTRIC BEADS.

The equipment of the bulbs is prepared apart, and the extremities of the wires terminate in loops, *O*, into which the hooks, *K*, at the ends of the couplings are very easily passed, since all that it is necessary to do is to raise the ball, *p*, in order to expose the hook (Figs. 2 and 3). The ball, upon falling back, conceals the mode of attachment.



Figs. 5, 6, 7.—DIFFERENT STYLES OF CHANDELIERS FORMED OF ELECTRIC BEADS AND CUT GLASS PENDANTS.

From this explanation, it is easy to see the advantage that it is possible, with a little taste and a knowledge of styles, to derive from conductors capable of adapting themselves to the most diverse forms, and to which the sources of light may be attached exactly at the places designated by the decorator.

The electric beads may be assembled in such a way as to form wreaths that may be fixed along friezes or against mirrors, and thus produce a splendid illumination. The entire light reflected by a mirror is irradiated through the cut-glass beads of the wreath, throughout the entire room, and, since the light is emitted in a horizontal direction, it will be sufficient for a large-sized parlor.

The same means are applicable to the transformation of existing apparatus and to the manufacture of chandeliers from which bronze is almost entirely excluded and which, thanks to the electric beads, afford an excellent utilization of the light.

The system is, as may be seen, of the greatest simplicity; and, with such elementary means, we obtain from incombustible materials, non-conductors of electricity and insensible to humidity, the following advantages:

(1) Impossibility of short circuits, since as the beads are pressed close against each other, the wires of opposite polarity are always separated by a sheeting of glass sufficient to prevent any contact.

(2) Insulation of the free ends of the wires when the lamp is removed.

(3) Possibility of increasing the intensity of the current, because of the wide cooling surface afforded by this method of mounting, which, in a certain measure, permits of obtaining around the wires a circulation of air that cannot be had with other conductors without running the risk of injuring the insulating materials.

(4) Facility of increasing or diminishing the number of lamps in service without the introduction of any modifications into the principal conductors.

(5) Facility of removing the mountings from one room to another, in order to enhance the decoration thereof, as on the occasion of an entertainment.

(6) Complete abolition of sockets and bottoms for the mounting of incandescent lamps.

As for the cost, that is naturally proportionate to the style of mounting and the number of beads and cut-glass pendants required by each *motif*.—Prepared especially for the Scientific American Supplement.

PHOTOGRAPHIC CHEMISTRY.

In his last presidential address to the Royal Photographic Society, Sir William Abney, speaking of the progress which had been made in three-color photography, said: The advent into the market of two such extraordinary sensitizers as pinachrome and homocol will probably make the year a memorable one. The latter is the newest offspring of the chemist, and has yet to be investigated in a quantitative manner, but the qualitative examination of it shows that it has capabilities which no single dye has yet shown. He (Sir William Abney) had already published in the photographic press the conditions necessary to obtain an ideal photographic plate for the three-color process, and shown that it is not the same as those necessary for

perfect monochromatic work where color luminosity is represented by various luminosity in black and white. The ideal three-color plate then will be a separate entity from that of the ideal orthochromatic plate. It appeared to him that in the near future we may have the means of attaining closely these ideals even if we have not got them already. There is one thing, however, that he should have wished, and that is, that these new sensitizers might have come from British factories rather than from German. Had we fostered technical education among the middle classes in the past, as we are now endeavoring to do, we might have looked at home for the production of such sensitive derivatives. As the aniline dyes were first born in England, it is bitter to think that for want of trained men nearly the whole of these industries have left for foreign shores. But we have to thank our foreign chemists for having given to the world these products of their research. It is better to have them now than to have to wait unlimited time, till our home industry and research have revived.

THE CEMENT INDUSTRY.*

By FREDERICK W. HUBER, Engineer of U. S. Geological Survey.

By mortar material is understood a material which when gaged with water is capable of producing a more or less plastic paste, which after a longer or a shorter time hardens to a solid mass, either by virtue of its absorption of CO_2 from the air, or by the process of crystallization. The mortar materials are divided into two general classes, i. e., hydraulic and non-hydraulic; that is to say, those capable of hardening under water and those hardening only in air. To the latter class belong quicklime and gypsum. Quick lime, CaO, and gypsum, $CaSO_4$, are both air mortars, their hardening or setting properties taking place only in the air; the one depending upon the absorption of CO_2, while the other depends upon crystallization for its "set."

Limiting our definition of a mortar material to materials used as binders in structural work, and excluding the so-called "cermanic" cements, we can say, generally, that they consist either of lime itself or of a mixture of lime and silicious materials (clay).

The original binder was quicklime, CaO, which was known and used by the ancients, many centuries before the Christian era. From the very beginning of civilization up to the rise of the Roman empire, quicklime was used as a binder, without an attempt at improvement. In fact, as long as man confined his building enterprises to structures in the air, it left little to be desired. But with the advent of the Roman, with his immense and magnificent enterprises in sanitary and hydraulic engineering, lime was found to be useless in subaqueous structures. Prompted by the imminent necessity for hydraulic mortar, the Roman, after some experimentation, hit upon a material, which, when added to slaked lime, imparted to it the peculiarity of hardening under water. Pliny and Vitruvius both mention this material as a volcanic ash occurring at the base of Mount Vesuvius, at a place called Puzzuoli, from which they named it "puzzolane." Pliny gives a formula for its use:

12 parts puzzolane.
6 parts quartzose sand.
9 parts rich slaked lime (well dried).

Mortar made from this cement was used in the famous aqueducts in and about Rome.

Up to the end of the eighteenth century puzzolane seemed to meet all the requirements as a hydraulic cement. At about this time Smeaton, an Englishman, set about searching for a material of local occurrence, to displace the expensive puzzolane for use in the building of the famous Eddystone lighthouse. He found that "Septaria Noduli," found along the river Thames, gave, when calcined and then pulverized to a very fine powder, a cement which possessed very energetic properties, and gave a mortar superior in strength to that of puzzolane. This he used as a binder in the construction of the famous Eddystone light.

Upon examining this material closer, he found that when treated with concentrated HCl, a residue was left which was found to consist of clay. He examined other materials for this characteristic, and found that all materials possessing it gave, when calcined and then pulverized, a cement of more or less hydraulicity. This natural mortar mixture, named "Roman cement," for no well-defined reason, rapidly displaced all others as a binder. Thirty years after Smeaton's discovery, Aspdin, also an Englishman, took advantage of the "tip" which nature had given Smeaton, and realized the function of the clay and limestone, and he attempted to make an artificial hydraulic cement. Accordingly he studied the natural Roman cements quantitatively, and found that the percentages of CaO, SiO_2, Fe_2O_3 and Al_2O_3 varied within well-defined limits. Accordingly he compounded limestone and clay in the proportions found in Roman cement, and strongly burned this mixture. The resulting product when pulverized gave a cement of remarkable hydraulic properties and superior in strength to anything known up to this time. This he called Portland cement, from the fancied resemblance of the hardened mortar to the Portland stone of that vicinity. Although the Portland cement of Aspdin differed from the Portland cement of to-day, yet it marked the beginning of an industry that has grown to gigantic proportions, and whose product yields a mortar which after a few years is equal to if not superior in strength to natural stone.

* From the California Journal of Technology.

CLASSIFICATION.

Mortar materials are classified according to the physical properties of their mortars: Non-hydraulic, Quicklime, Lean lime, Hydraulic, Hydraulic lime, Roman cement, Portland cement, Puzzolane cement.

The non-hydraulic owe their "set" to the absorption of CO_2, the second depending upon the process of crystallization.

NON-HYDRAULIC CEMENT.

Quicklime, CaO: This, as before stated, is an air cement. It is obtained by the simple burning of the purer varieties of limestone to drive off the CO_2. One peculiarity of this mortar material is that the merit of the burned product depends on the physical properties of the raw material from which it is burned, viz., that burned from a dense crystalline rock is stronger than one burned from porous chalk, the purity of each being the same. When limestone contains more than 10 per cent clay the lime obtained by burning it is called lean lime. It slakes very much slower than the quicklime and with less evolution of heat.

Between the hydraulic and non-hydraulic mortar materials lies gypsum. Gypsum as a mortar material is seldom used, but in the manufacture of Portland cement it plays a very important part which will be spoken of under a subsequent heading.

HYDRAULIC CEMENT.

Technically, limestones are classified according to their degree of purity, clay being the foreign substance usually occurring mixed with the limestone.

Limestone with but a trace of clay is considered for technical purposes as pure. That containing up to 15 per cent clay is considered as a lime marl. That containing 30 per cent is considered as marl. That containing 75 per cent is considered as clay marl. Everything containing above 75 per cent of clay is considered as clay.

HYDRAULIC LIME.

When limestone containing from 18 to 25 per cent of clay is burned, there results a product which in lump form is capable of slaking and hardening under water. In the burning of this material the temperature should only be high enough to drive off the CO_2 from the limestone; the strongly basic CaO thus formed combines with the clay to form a silicate of calcium. If the temperature is higher than that required for the expelling of the CO_2, incipient infusion will take place, and the resulting product will be useless as a mortar material. Like lime, the excellence of the burned product depends upon the physical properties of the stone from which it is burned.

The better varieties of hydraulic lime consist of practically pure silicated calcium containing:

	Per cent.
SiO_2	22.6
Al_2O_3	2.7
Fe_2O_3	0.8
CaO	65.6
MgO	1.5
Alkali	0.19
Ignition loss	6.4

Physical properties: The hydraulic limes are usually of a light yellow color with sp. g. equal 2.9, and ignition loss going as high as 8 per cent. Mortar made from a mixture of one part hydraulic lime to three parts sand, after three days in air and the remainder of time under water, shows the following strength:

After 7 days	28 days	365 days
Ten..... 65 lbs. per sq. in.	1?0 lbs. per sq. in.	302 lbs. per sq. in.
Com 350 lbs. per sq. in.	680 lbs. per sq. in.	1950 lbs. per sq. in.

Mortar made from neat cement shows but very little strength.

ROMAN CEMENT.

Next in order after the hydraulic limes come the Roman cements. The material from which it is burned contains the highest percentage of clay of the natural hydraulic limes, and from 50 to 75 per cent $CaCO_3$. The finished Roman cement always contains some free lime, which distinguishes it from the artificial Portland cement.

Its composition is a somewhat variable one, but is confined within the following limits:

	Per cent.
SiO_2	0.23—26.8
Al_2O_3	8.8 —10.3
Fe_2O_3	1.9 — 5.9
CaO	0.58—60.0
MgO	0.3 — 1.8
Alkali	0.6 — 1.22

The composition approaching close to that of Portland cement.

Burning: The temperature for the burning of the Roman cement, although somewhat higher than that for hydraulic lime, must, however, not be sufficient to cause sintering. The burned product will not slake in lump form, but must be ground to a very fine powder before it can be used as a mortar material.

Physical properties: Roman cement hardens or "sets" in about 30 minutes. Its color is light yellow. Sp. g. equals 2.7. Mortar made of one part Roman cement and three parts sand after one day in air and the remainder of time under water, shows the following strength per square inch:

After 7 days	28 days	365 days
Ten... 172 lbs per sq. in.	220 lbs. per sq. in.	432 lbs. per sq. in.
Comp 1340 lbs. per sq. in.	1850 lbs per sq. in.	4580 lbs. per sq in.

From this it will be seen that Roman cement is decidedly superior to the hydraulic lime in strength. Of the natural cements the Roman is the best and most used, both in Europe and America. It is extensively made in Ulster County, New York, as "Rosendale," and also in Kentucky and Tennessee. Its greatest disadvantage is its poor keeping quality, due to the presence of free lime, which eventually absorbs CO_2 and becomes inert. But its cheapness and strength find for it a large field for massive work. It is an especially good mortar for subaqueous structures in salt water. No "Rosendale" is made west of the Mississippi River, although the materials for its manufacture undoubtedly exist in abundance on the Pacific slope.

ARTIFICIAL HYDRAULIC CEMENTS.

In this category are included first lime with natural admixtures, such as puzzolane, santorian earth and trass, secondly lime with artificial admixtures, such as slag, pulverized brick and burnt clay.

Logically Portland cement would be included, but it is of enough importance to be considered in a class by itself.

Lime with Natural Admixtures: Puzzolane, santorian, and trass cements are each the result of mixing finely ground slaked lime with the respective puzzolane trass and santorian earths; a normal mixture in each case depending upon the physical properties of the material to be added to the lime.

These cements are pre-eminently for subaqueous structures and are of but little value when used in air. Usually they are mixed 60 to 80 parts of the "earth" with 40 to 20 parts slaked lime.

Their average strength after 3 days in air and 25 days under water is 200 pounds per square inch in tension, 1,350 pounds per square inch in compression.

The Slag Cement: The basic slag which is drawn from the blast furnace at a white heat and granulated by being plunged into cold water, yields a product which when ground, dehydrated and added to slaked lime produces a cement of remarkable strength for submarine work.

Preparation: The granulated slag must be finely pulverized and dehydrated before being added to the slaked lime. Attempts have been made to utilize the combined water to slake the admixture of lime, but without success. The proportion of slag to slake lime is a variable one depending entirely upon the degree of basicity of the slag; the ratio CaO/SiO_2 in the slag should not be less than unity. The higher the ratio Al_2O_3/SiO_2, the higher will be the per cent of lime that can be added. These cements are light gray in color; very similar to the Portland cement. Their sp. g = 2.7. They harden quite slowly at first, but eventually attain a remarkable strength under salt water. A mortar of the proportion 1 to 3 after 3 days in air and the remainder of a time under salt water showed the following strengths:

After 7 days	28 days	365 days
Ten... 170 lbs. per sq. in	320 lbs. por sq. in	500 lbs. p r sq. in.
Comp. 1500 lbs per sq. in	3000 lbs. per sq. in.	6800 lbs. per sq. in.

PORTLAND CEMENT.

Portland cement as defined by the best authorities is: "The artificial product resulting from the burning, to incipient vitrifaction, of finely ground and intimately mixed materials. In fixed proportions containing lime, silica, iron oxide and alumina; and grinding the resultant clinker to an impalpable powder."

In the early days of the Portland cement industry, the manufacture was carried on in a most unscientific manner; working by rule of thumb alone. The result of such methods was the production of some good and a great deal of very poor cement; the good cement being due, not to the intelligence of the manufacturer, but to the goodness of nature in supplying ideal raw material, already compounded.

Dr. Michailias, a German chemist, undertook to study the problem of compounding the raw cement mixtures with the characteristic "Grundlichkeit" of his race. As a result of very many painstaking and exact experiments he determined the limit between which the constituents of the cement clinker could vary to still produce a sound product. He determined the ratio of $lime/(SiO_2+Al_2O_3)$ and found that it must be confined within the limits of 1.8—2.2. This ratio is known as the hydraulic index. Above these limits the cement is over-limed, i. e., containing uncombined CaO which produces disintegration after a few days. Below this limit the cement is under-limed and will possess but feeble hydraulic properties.

Accordingly he determined the qualitative and quantitative composition of a good sound cement to be as follows:

	Per cent.
SiO_2	19 to 26
Al_2O_3	4 to 10
Fe_2O_3	2 to 4
CaO	57 to 66
MgO	0 to 5
SO_3	0 to 2
Alkali	0 to 3

CHEMICAL COMPOSITION OF THE CLINKER.

The chemical combination under which the lime, silica, aluminium and iron enter has as yet not been definitely determined. LeChatelier, after a series of experiments upon thin sections of clinker, concluded that essentially clinker was a mixture of tri-calcium silicate (3CaO) (SiO_2) and tri-calcium aluminate (3CaO) (Al_2O_3). But he failed to synthetically prepare the

tri-calcium silicate by directly heating silica and lime. He, however, suggested that this might be accomplished indirectly by the heating of fusible silicates with lime. The results of his attempted synthesis of the tri-calcium silicate was a mixture of the mono and di-silicates of lime. Messrs. S. B. and W. B. Newberry, two of our most eminent and able cement chemists, in a series of researches as to the probable constitution of clinker, arrived at conclusions quite different from those of Le Chatelier. They synthetically prepared the various silicates and aluminates directly, by heating in a Fletcher gas furnace mixtures of very finely pulverized quartz and $CaCO_3$ in different molecular proportions, and examining the setting and hardening properties of the compounds thus obtained. While agreeing with Le Chatelier that the predominate element of clinker is $3CaO + SiO_2$, they found on the other hand no difficulty in directly preparing this compound by heating together silica and lime in the molecular proportion of 1/3, and they concluded that the calcium and alumina were combined as a di-calcium aluminate instead of the tri-calcium aluminate. From this experiment they concluded:

First: Lime combined with silica in the molecular proportions of 1/3 gives a product which has constancy of volume and good hardening properties. While when combined in the proportion of 1/3—½ the product is not sound and shows signs of disintegration at the end of a very short time.

Second: Lime when combined with alumina in the molecular proportion of 2/1 gives a quick setting product which has consistency of volume and good hardening properties. While 2.5/1 gives a product that is very unsound.

Tri-calcium silicate $(3CaO)\ (SiO_2)$ corresponds to 2.8 parts of lime and 1 part silica, and the di-calcium aluminate corresponds to 1.1 parts of lime to 1 part of alumina. From this they established the formula representing the maximum of lime which should be present in a well-balanced Portland cement:

$$\text{Per cent of lime} = \text{per cent } SiO_2 \times 2.8 + \text{per cent alumina} \times 1.1.$$

This formula agrees with the composition of the best American and foreign cements, while Le Chatelier's formulæ

$(CaO + MgO)\ /\ (SiO_2 + Al_2O_3)$ is equal to or less than 3

$(CaO + MgO)\ /\ (SiO_2 - Al_2O_3 - Fe_2O_3)$ is equal to or greater than 3

were found to give results too high in lime, and the cement compounded according to it is unsound.

Very recently Clifford Richardson, in a paper entitled, "Constitution of Portland Cement Clinker from the Physico-Chemical Standpoint," has attempted the solution of the problem by a new and promising method. It is not proposed, here, to discuss this paper or to unduly criticise it, but to give only a brief outline of the principles involved and the inferences drawn. In his study of the problem he has employed the principles so successfully employed in the study of steel by Howe and Juptner, viz., the principle of solid solutions. He prepared thin sections of different synthetic clinkers and differentiated in each four distinct optical individuals, which had been previously noted by Thornebohn as alit, celit, belit, and felit. Alit and celit were found to be the predominating elements. He concludes from his investigations that the clinker is essentially a solid solution of aluminates in tri-calcium silicate, the aluminates not being sufficiently concentrated to form a saturated solution. He compares the aluminates in the cement with the carbon in the steel. A steel low in carbon is a mild steel, and so "a cement low in alumina is a mild cement," etc. He has applied the principle of solid solutions of molten (liquid) solids to materials which do not reach this stage of fusion, i. e., to a heated mass that is just at incipient fusion, supporting his theory by the principle of diffusion of solids at ordinary temperatures—for instance, the diffusion of gold into lead under pressure and solid hydrous sodium sulphate and barium carbonate, at ordinary temperatures. While it is possible, even probable, that diffusion at 1,650 deg. C. (burning temperature of clinker), which is below the actual melting point of the material, will take place more readily than at ordinary temperatures, when the materials are finely divided, yet generalities should not be too hastily established. Mr. Richardson is at present engaged in research work along these lines, which will, it is hoped, clearly demonstrate the applicability of these principles of solid solutions to mixtures which are in the semi-fused state. Some of his conclusions are far from agreeing with the best practice of the day, so that for the immediate present we will have to content ourselves with the formulæ established by the Newberrys, which give results in harmony with the best practice.

THEORY OF THE HARDENING OF CEMENT.

Le Chatelier examined thin sections of hardened cement and found it to consist of hexagonal plates of crystallized $Ca(OH)_2$ imbedded in a matrix of hydrated mono-calcium silicate $CaSiO_3 + 2H_2O$. He concluded that the tri-calcium silicate when mixed with water reacts to form a hydrated mono-calcium silicate and $Ca(OH)_2$ according to the equation:

$$5\ Ca_3\ SiO_5 + 9\ H_2O = 2\ (CaSiO_3).\ 5\ H_2O + 4\ Ca\ (OH)_2.$$

The $Ca(OH)_2$ probably reacting further upon the calcium aluminate forming $Ca_4Al_2O_7 12H_2O$, hydrated basic calcium aluminate, according to $Ca_3\ Al_2O_6 + Ca\ (OH)_2 + 11H_2O = Ca_4\ Al_2O_7\ 12H_2O$. The ultimate hardening of the cement is most probably due to the first reaction, while the initial "set" is probably due to the second reaction. The small percentage of alkalies occurring in commercial clinker quickly facilitates this reaction in the wet way.

In addition to the chemically essential lime, silica and alumina there occurs in cement ferric oxide, magnesia, sulphuric anhydride and alkali. These are not essentials from a purely chemical standpoint, but the iron and alkali greatly expedite the process of burning. Iron acts as a flux, facilitating the burning, and to a less degree the alkalies act in the same way. They are, however, instrumental in bringing about the final hardening of the cement as explained above.

The effect of the MgO in the cement has until recently been considered as detrimental when present in quantities exceeding 3 per cent. But recently the German cement chemists have definitely decided that in a properly burned cement magnesia can be present in the combined form up to as high as 5 per cent without impairing the soundness of the resulting product. In fact, Messrs. Dykerhoff have replaced the lime in a synthetic cement by its equivalent in MgO and obtained a perfectly sound product. The SO_3 in a clinker is due usually to a small amount of pyrite in the clay and to the sulphur in the fuel. A small amount of CO_2 is also found in cement, but never exceeding 0.3 per cent.

RAW MATERIALS.

Roughly speaking, the raw cement mixture contains 75 per cent calcium carbonate, and 20 per cent clay. The raw materials used in the United States to produce cement mixtures are of six kinds: 1. Argillaceous limestone and pure limestone. 2. Marl and clay. 3. Chalky limestone and clay. 4. Pure limestone and clay or shale. 5. Caustic soda waste and clay. 6. Slag and limestone.

Argillaceous Limestone: Evidently a stone of this class consisting of 75 per cent $CaCO_3$ and 20 per cent clayey matter (SiO_2, Al_2O_3 and Fe_2O_3) would yield without further addition to it, when burned and ground, a good Portland cement. The stone from which two-thirds of the cement used in the United States is made approaches closely this ideal composition; namely, the argillaceous limestone of the Lehigh District, which is a limestone of the Trenton (Lower Silurian) age. In composition it varies from 60 to 80 per cent $CaCO_3$ and from 40 to 20 per cent clayey matter. Its magnesia content is comparatively high; 3 per cent to 6 per cent. Underlying the beds of argillaceous limestone is a stratum of purer limestone, running from 85 to 96 per cent $CaCO_3$. Both materials are quarried easily and cheaply. To the argillaceous limestone is added a small percentage of the purer limestone to bring the cement mixture up to the proper composition. Such a mixture, owing to the fact that about four-fifths of it is composed of a natural mixture, permits of coarser grinding before burning than would a purely artificial mixture.

Marl and Clay: Marl occurs in the Central Western States as a very pure calcareous marl, usually filling old lake basins and being due to the precipitation of the $CaCO_3$ from solution by the action of vegetable and animal life. They are used extensively in Michigan, North Indiana and Central New York.

These marls contain from 88 to 95 per cent limestone, and from 0.3 to 2 per cent iron, alumina and silica. They are readily excavated, but carry a great deal of water, very often as much as 40 per cent, resulting in a large consumption of fuel in drying. In compounding the cement mixture, clay is added to the undried marl, well mixed and then dried before burning.

Chalky Limestones and Clay: This combination is used in three distinct and widely separated areas; Alabama, Mississippi, Texas, North and South Dakota, Nebraska and Colorado. This chalky limestone or rotten rock is usually of the Cretaceous Age, varying from a rather pure calcium carbonate low in MgO and clayey matter down to an impure clayey limestone requiring little additional clay to give it the proper composition for Portland cement mixture. Materials of this class, owing to the ease with which they can be pulverized, and to the absence of water, are a very superior and cheap Portland cement material.

Pure (hard) Limestone and Clay or Shale: This combination is used in many mills in the East, and also on the Coast. The expense of quarrying hard limestone is of course greater than that of excavating soft marls, but on the other hand little or no drying need be done on the stone. Limestone and clay are dried to drive off the quarry water and mechanically combined water, and then mixed in the proper proportions either before or after the first grinding. The material resulting from this combination is usually very uniform and from a chemical standpoint is comparatively easy to control.

Caustic Soda Waste and Clay: The precipitated calcium carbonate which is a by-product in the manufacture of alkali has received considerable attention in both England and the United States as a constituent in a Portland cement mixture. The clay is added to the soda waste in the right proportions, just as in the other combinations of raw materials.

Slag and Limestone: Blast-furnace slag running high in lime is a valuable cement material; the slag is a by-product in the manufacture of steel. It is granulated by plunging it in a white hot state into cold water. In doing this it takes up from 20 to 40 per cent of water, which must again be driven off before it is mixed with the limestone and ground. This disadvantage is partly counterbalanced by the lime being present as calcium oxide, this saving somewhat in the heat required for burning.

Process of Manufacture: The process of manufacture is done in five distinct stages: 1. Quarrying the raw materials. 2. Drying and mixing. 3. Grinding of the raw material. 4. Burning. 5. Grinding of the clinker.

Preparation of the Raw Material for the Kiln: The raw material as it comes from the quarries is either compounded in the proper proportions before or after drying, depending much upon local conditions. In one of the largest mills on the Pacific Coast, the raw materials used are very pure, hard limestone, and a residual clay, the limestone carrying but little moisture, while the clay during the rainy season carries as much as 30 per cent of water. An average sample is taken about every hour of the limestone and clay and the percentage of water in each determined, and this figured into the equivalent of the dry material. They are compounded before drying; after compounding they are run into a rotary dryer and subjected to a temperature of about 300 deg. C., and from here they are carried in trough conveyors to the Krupp ball mills, where they are pulverized to about 30 mesh stuff. From the ball mill the material is fed to the tube mill, where it is ground to such a degree of fineness that at least 96 per cent passes a 100 sieve, and 75 per cent passes a No. 200. From here it passes to the kilns.

The grinding of the raw material is of the greatest importance, as on it depends the quality and the ease with which the materials will unite to form a good clinker. The argillaceous rocks of the Lehigh Valley, however, permit of coarser grinding, inasmuch as the materials are naturally intimately mixed. Where this stone is used for raw material, the proper percentage of $CaCO_3$ is added before drying and grinding, the amount being determined hourly from the analysis of the rock. The cement mixture contains from 74 to 77½ per cent calcium carbonate. This when figured into cement gives a 60 and 63 lime. Where marl is used the clay is added to the wet marl and this thoroughly churned by machinery to insure intimate mixing and then run out on drying floors. The clay through the action of water assumes a finely divided state and mixes very readily and thoroughly with the wet marl. This wet marl after partly drying is passed on to the kilns. Whatever raw material is used, the problem to be solved is the obtaining of an intimately mixed and finely pulverized raw mixture of the proper chemical composition. The next step after the compounding of the raw mixture is the burning. This is accomplished entirely, in the United States, in the rotary kilns. These kilns vary from 5 feet in diameter by 60 feet long up to 6 feet in diameter and 120 feet long. The axis of the kiln is inclined to the horizontal with about a slope of a half inch to the foot, and the speed at which they turn varies from 2 to 4 revolutions per minute. The fuels used are either oil or pulverized coal, blown into the kiln under pressure. The flame in either case is focused along the axis of the kiln (in space). The raw material as it enters the kiln is gradually warmed up until the temperature of calcination is reached. At this point the very caustic calcium oxide which is practically in a nascent state reacts with the silica, iron and alumina, and some heat is thus generated by the chemical combination. By this time it is about ready to enter the so-called burning zone of the kiln, which in the ordinary kiln is from 18 to 24 inches long, and in passing through this it is semi-vitrified, then rolls out of the kiln and is conveyed by bucket conveyors to the cooling towers, where it is sprinkled with water to facilitate the cooling. From the clinker pits, which are under the cooling towers, the clinker is mixed with about 2 per cent of gypsum to retard its "set," and is then passed on to the Krupp ball mills on the finished end and from the ball mills to the tube mills in precisely the same manner as on the raw end. The ground clinker should be of such fineness that at least 70 per cent would pass a 200 sieve and at least 90 per cent would pass a 100 sieve. The cement is then run into large storage bins and aged from 30 to 60 days, at the end of which time it is ready to be shipped to the market.

Physical Properties of the Clinker: A well-burned clinker is of a greenish black color and of a honey-combed structure. Its specific gravity is between 3.1 and 3.19. If it is above this it will have the appearance of a vitreous mass and is then said to be over-burned. The hardness of well-burned clinker is about 8.7. An under-burned clinker is of a chocolate brown color and its specific gravity is below 3 and its hardness about 6. Under-burned clinker eventually goes over into a normal clinker if allowed to weather for several months.

Physical Properties of Portland Cement: Portland cement is light gray in color, with specific gravity = 3.1 to 3.19. A mortar made of neat cement will after one day in air and the remainder of the time under water show the following strength:

After 7 days	28 days	365 days
Ten ...500 lbs. per sq. in	800 lbs. per sq. in.	1100 lbs. per sq. in.
Comp. 4000 lbs. per sq. in.	7000 lbs. per sq. in.	12000 lbs. per sq. in.

A mortar made of 1 part cement to 3 parts sand, one day in air and the remainder of the time under water:

After 7 days	28 days	365 days
Ten....175 lbs. per sq. in.	250 lbs. per sq. in.	500 lbs. per sq. in.
Comp 1200 lbs. per sq. in.	4200 lbs. per sq. in.	8000 lbs. per sq. in.

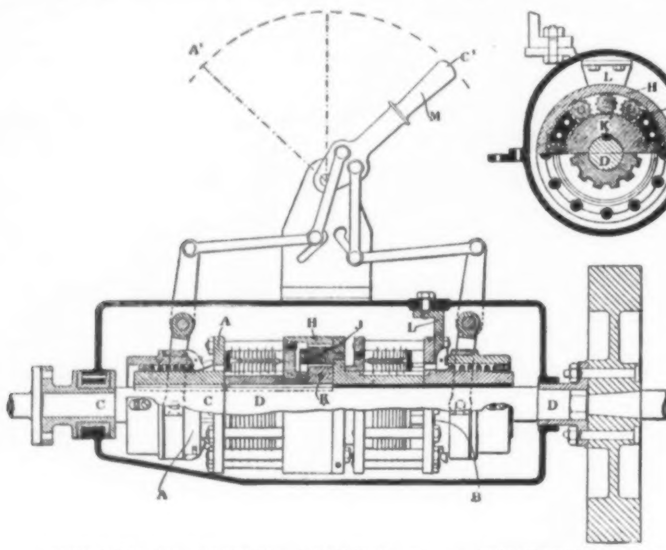
Portland cement to be a safe building material should contain no free lime, as free lime upon hydrating expands and causes disintegration, thus making as much a destructive agent as a constructive one. Cement containing free lime, when spread out in a thin

layer and allowed to air for several days, will become perfectly safe. Cement is most usually used in a mixture consisting of cement, sand and broken stone, in varying proportions, which is known as concrete. For standard concrete as used for large and important structures, the concrete aggregate is composed 1 part cement, 3 parts sand and 6 parts broken stone. This mixture attains its ultimate strength in about five years, at the end of which time it is equal, if not superior, to most natural building stones. The application of concrete in monolithic structures is so well known that it will not be here dwelt upon.

A NEW FORM OF FRICTION CLUTCH.*

By Emile Guarini.

A very interesting form of friction clutch has recently been devised and carried out by Prof. H. S. Hele-Shaw, Liverpool. The principle of the apparatus is very easy to understand.



HELE-SHAW CLUTCH APPLIED TO A REVERSING GEAR.

Suppose a circular disk of metal to be corrugated, the section of the corrugation being the frustum of a cone, and that the disk is placed upon another one similarly corrugated. It will be observed that not only do portions of the frusta not make contact with each other, but there is also a space left between the flat portions of the disks. By placing these disks together and turning one alternately to the other, an amount of friction is produced which depends on the acuteness of the angle of the frusta. If a number of these plates are now placed in a box of the type of the "Weston" coupling, so that the plates alternately engage with two sleeves, one connected with the driver and the other with the follower, it will be found: First, there is very considerable gripping power; second, there is a tendency to part rapidly with heat, owing to the separation of the disks of metal.

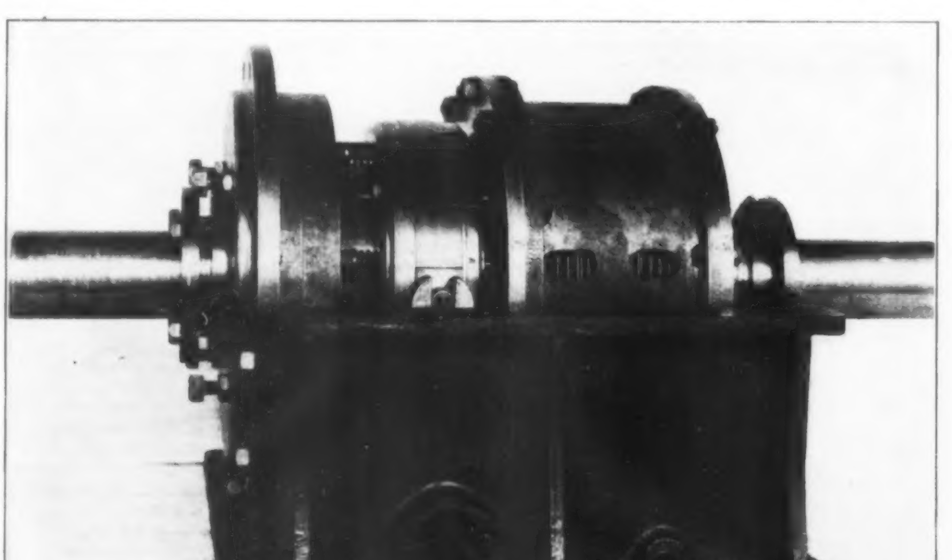
In order to insure efficient lubrication of the surfaces in contact, the faces of the plates are drilled. The number of plates in a given space depends upon the angle of the corrugation; thus four plates with 30 deg. occupy the same space as six plates with 50 deg. These four plates, however, give a better grip than the six plates with 50 deg. and have the great advantage of allowing a freer circulation of liquid. The plates are also much more rigid with the more acute angle, and indeed this increased rigidity appears to be closely associated with their greater gripping power.

When the standard type of clutch for shafts up to two inches diameter is used, the shaft is divided, the outside case being keyed to the left-hand piece of shafting, and driving the set of plates having external driving teeth, the core keyed to the right-hand shaft driving the plates with internal driving teeth. Pressure is applied to the plates as follows: The sliding sleeve of the clutch containing a coil spring is fitted with pins which project through the outside case of the clutch; these pins press against a flat disk, which in turn presses against the plates, causing the clutch to drive.

When the operating lever is worked so as to release the plates, the ring encircling the sleeve withdraws the trigger pins from the holes into which they fit; the spring pressing on the opposite end of the trigger pin causes the trigger to fly up, and the clutch is thereby kept out of operation. By moving the lever so as to force the ring against the trigger, the pin end falls into the hole opposite to it, and the coil spring is then allowed to transmit its pressure to the plates.

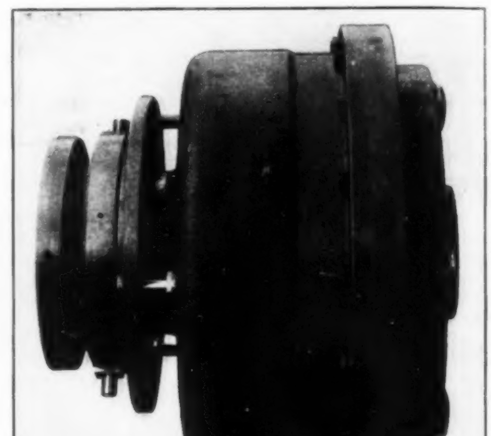
The action of the type of clutch fitted to a three-inch shaft is similar to that just described. The triggers, however, are worked by separate coil springs; the pressure is also applied to the plates by means of separate springs instead of a single one. A considerable amount of lubricant can be contained in this clutch, owing to the construction of the casing.

Another clutch transmits 80 horse-power at 60 R. P. M. One of the conditions of working of this clutch is that it shall run for at least two hours daily, transmitting its full force when slipping 50 per cent, that is, the shaft running at 30 R. P. M., with the main shafting running at its full speed of 60 R. P. M.

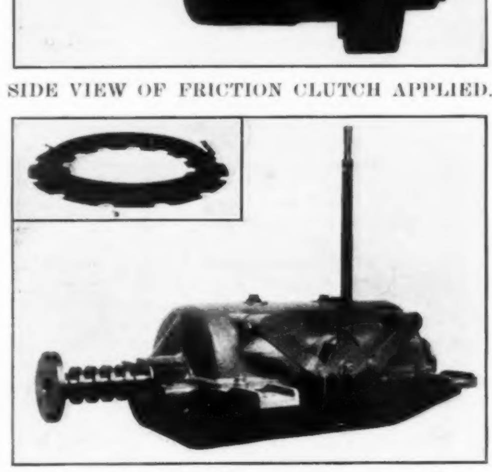


THE HELE-SHAW FRICTION CLUTCH MOUNTED ON A DRIVING-SHAFT.

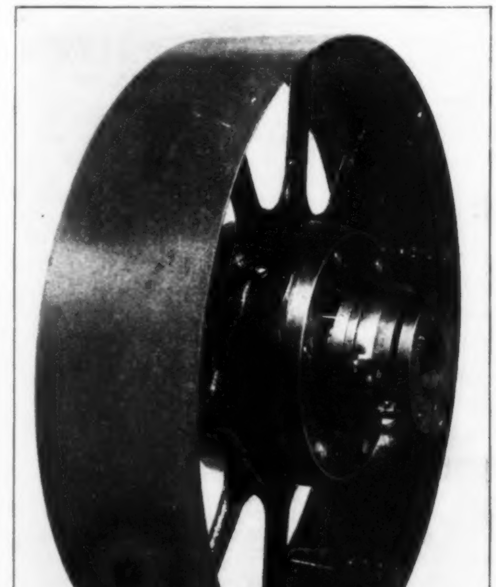
The clutch is the chief factor in a wheel-train reversing gear; Mr. Hele-Shaw has recently designed such a reversing gear, in which the new clutch is employed. This reversing gear, shown in the accompanying cut, consists of two clutches, *A* and *B*. The outer case of the clutch, *A*, is keyed to the reversing shaft, *C*, which may be a propeller shaft, the core of *A* being keyed to the engine shaft, *D*. Inside the rim of the outer case of *A* teeth are cut in the direction of the shaft, forming an annular wheel, *H*. They also gear with the wheel, *K*, keyed to the engine shaft, the three together forming an epicyclic train. The outer case of *B* is held stationary, being fixed to the frame of the machine by a bracket, *L*. The gear operates as follows: When the lever, *M*, is in position, C', clutch *A* is made free and clutch *B* comes into action. The core of *B* carrying the pinions, *J*, is now fixed to the outside case of clutch *B* (which is permanently at rest), and, as the core of *B* is free on the engine shaft, the toothed wheel keyed to this shaft at *K* transmits motion to the pinions, which, being also in gear with the outside case of *A*, causes the shaft, *C*, to which *A* is fixed, to rotate in a reverse direction, and at a slower speed than that of the engine. When the operating lever, *M*, is in mid-position, both clutches are inoperative and the reversing shaft is at rest. When the lever, *M*, is in position A', clutch *B* is free, at the same time the plates in clutch *A* are caused to grip, and as the outside case of *A* is keyed to the reversing shaft, and the core of *A*



SIDE VIEW OF FRICTION CLUTCH APPLIED.



20-HORSE-POWER REVERSING CLUTCH.



THE CLUTCH APPLIED TO A FLYWHEEL.

* Specially prepared for the Scientific American Supplement.

to the engine shaft, the two rotate together in the same direction. The toothed gearing at *H*, *T*, and *K* now rotate as a fixed mass, the teeth themselves not being in operation. The presser rings of clutches *A* and *B* on this gear are fitted with the spring and trigger arrangement described previously. The locking system of operating links and levers renders it impossible for both clutches to grip simultaneously, no matter how suddenly the operating lever *M* may be moved from one extreme position to the other. The inclosing case of the whole gear acts as an oil bath.

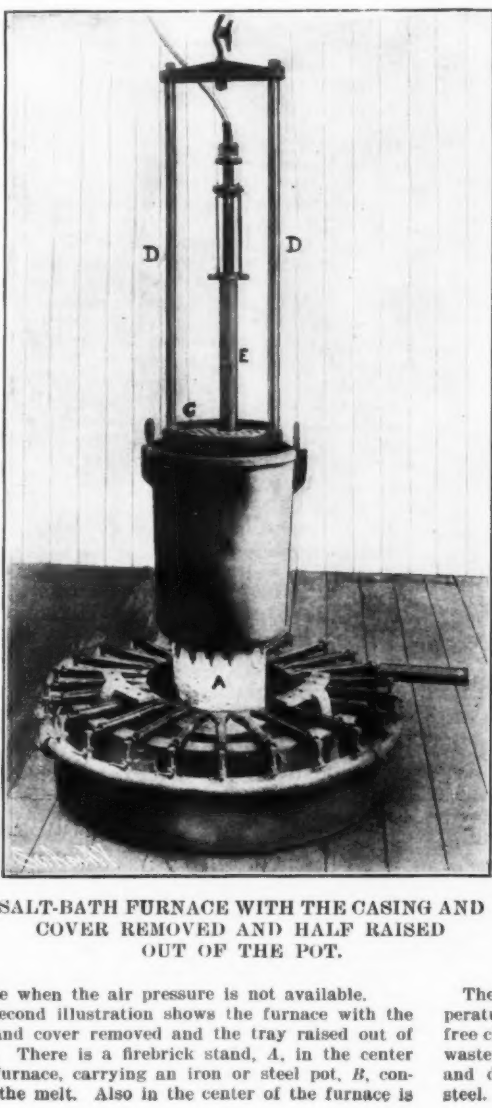
A SALT-BATH FURNACE FOR STEEL HARDENING.

By the English Correspondent of SCIENTIFIC AMERICAN.

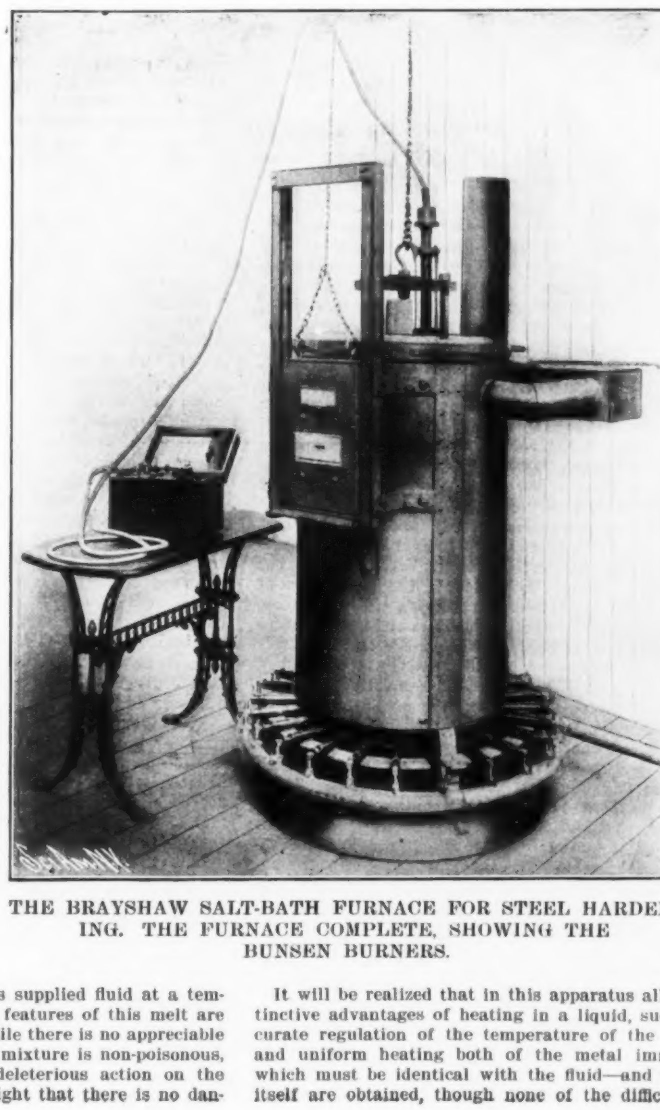
EVERY tool maker and user is aware of the many difficulties of accurate hardening, the most prominent being the loss of efficiency when the steel is not hardened at the exact hardening point, and the irregularities that may arise in the tool or piece of metal. These irregularities are insuperable in all processes, owing to the inherent defects of the system adopted, for hardening by judgment is affected by changes in light and several other circumstances over which the hardener has no control. Under these circumstances the utilization of an accurate mechanical means of tempering is a distinct and acceptable advantage.

With a view to surmounting this complex problem, Mr. Brayshaw has for several years been experimenting with a process, mechanical and certain in its action, and the outcome of his investigations is an ingenious device, which has been placed on the market by Messrs. Churchill & Co. of London. In this apparatus the inventor utilizes a fusible salt liquid for heating purposes. This is by no means a new application, since attempts to employ a bath of fusible salts have been made for many years. In some cases the endeavors have been attended with success, but the difficulties attending the employment of the same have been of such a nature that the method has not devolved into general practice. The greatest obstacle is in connection with the fusible salts themselves, and the correct design of furnace to be used therewith. Mr. Brayshaw, however, has surmounted the difficulty by the discovery of a suitable salt for use with the fusible salts, and by the design of a special furnace. This latter is a thoroughly workable apparatus, as continued tests have conclusively proved, and is of a novel design.

The general appearance of the Brayshaw furnace may be gathered from the accompanying illustrations. It consists of an iron casing lined with firebrick, with a removable firebrick cover in halves. The furnace is operated with coal or producer gas, either with or without blast, according to the requirements of the operator. When equipped for the blast, a few Bunsen burners are provided, so as to keep the furnace hot at



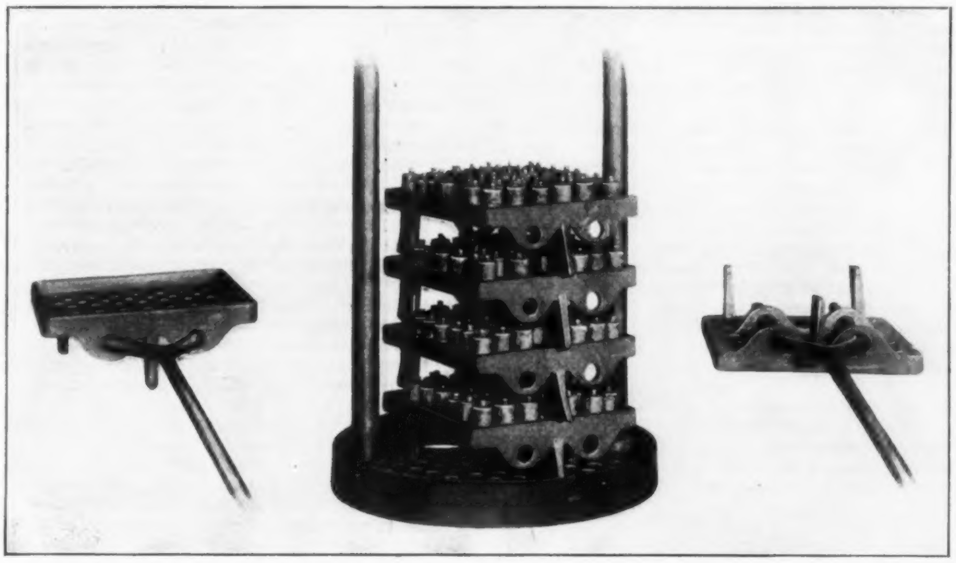
SALT-BATH FURNACE WITH THE CASING AND COVER REMOVED AND HALF RAISED OUT OF THE POT.



THE BRAYSHAW SALT-BATH FURNACE FOR STEEL HARDENING. THE FURNACE COMPLETE, SHOWING THE BUNSEN BURNERS.

any time when the air pressure is not available.

The second illustration shows the furnace with the casing and cover removed and the tray raised out of the pot. There is a firebrick stand, *A*, in the center of the furnace, carrying an iron or steel pot, *B*, containing the melt. Also in the center of the furnace is a counterbalanced tray, *C*, which can be raised out of or lowered into the pot at command. This tray is supported by the rods, *D*, which pass through holes provided in the cover of the apparatus. When inserting or withdrawing metal from the furnace, this tray is raised just clear of the melt to the level of the door,



THE BRAYSHAW SALT-BATH FURNACE FOR STEEL HARDENING. THE GRIDS ARE PLACED ONE ABOVE ANOTHER FOR THE CONVENIENT AND RAPID TREATMENT OF SMALL ARTICLES.

so that the work may be handled in the ordinary way. One important point, however, is that the tray, when raised out of the melt, is still within the upper part of the furnace, so that it remains at a fairly constant heat. By this arrangement the work can be lifted out of the pot and immersed again repeatedly without any danger of disturbing the temperature of the melt.

For convenience, and to enable large numbers of small articles to be treated rapidly, special grids are provided. The articles are placed on these grids, which are superimposed on the rising and falling tray, and at the same time owing to their design, enable the melt to flow evenly and readily among the articles under treatment, so that they acquire the same temperature as the melt. For handling these grids a special fork is used.

The melt of fusible salts is supplied fluid at a temperature of 700 deg. C. The features of this melt are free circulation in the pot, while there is no appreciable waste by volatilization. The mixture is non-poisonous, and does not exercise any deleterious action on the steel. It is furthermore so light that there is no danger of the article immersed for treatment floating on the surface. The articles when placed on the tray are simply lowered into the melt, and require no hooks or attachments of any description to secure them during the heating process. This is a distinct advantage over the hardening method with molten lead. The latter, owing to its high specific gravity, 11.4, necessitates steel articles of about 8 specific gravity being held in immersion with extraneous attachments.

Another important superiority of this melt over lead is that it is much less severe in its action, owing to the high fusion point, so that when a cold article is immersed the salts solidify immediately around it, and protect the article from too rapid heating. As the article becomes heated, the salts melt off. Furthermore, in bulk the melt is much less costly than lead. The heating process, however, is not accelerated in any way, occupying approximately the same time as the ordinary furnace, but it has the advantage of enabling several articles to be treated simultaneously, thereby rendering it possible for a greater quantity of work to be passed through the furnace in a given time.

It will be realized that in this apparatus all the distinctive advantages of heating in a liquid, such as accurate regulation of the temperature of the solution, and uniform heating both of the metal immersed—which must be identical with the fluid—and the fluid itself are obtained, though none of the difficulties or

obstacles attending the utilization of the liquid are present.

A pyrometer, Whipple temperature indicator, and Callendar recorder are utilized in connection with the furnace. The electrical pyrometer, *E*, is passed through the furnace cover, and hangs through a hole in the rising and falling tray in a stationary position. The lower end containing the essential part of the instrument is continuously immersed in the melt while the furnace is in operation. As the melt is stirred when the tray is moved, the temperature around the work under treatment and that of the pyrometer are precisely the same.

The pyrometer is of the resistance type, depending on the way in which the electrical resistance of a coil of wire is affected by its temperature. A fine platinum wire is wound on a mica frame, and connected to the indicator or recorder frame by stouter wires. The platinum coil is protected from the action of fumes and mechanic damage by a porcelain tube protected by a steel sheath. The elimination of the effect of temperature on the stem and wires connecting the thermometer to the temperature measuring apparatus is assured by an arrangement of compensating leads. Protected wires lead from the upper end of the pyrometer to the indicator, which shows the temperature within 1 deg. Cent.

The Whipple temperature indicator enables direct readings to be obtained either on the Fahrenheit or the Centigrade scale without the necessity of any corrections of any kind. The application of this instrument is of great assistance to the operator, who can without any special training obtain the temperature of the melt in a minute or two.

With the Callendar recorder a continuous record of the temperature is obtainable, and it can be read off at any time without disturbing the record. Again, it also enables the operator to ascertain at a glance whether the requisite temperature is being maintained or otherwise. This apparatus is of the general type with the recording pen, which is controlled by electromagnets controlled by the variations in the resistance of the platinum coil of the pyrometer, which in their turn are due to the variations in the temperature of the melt in which the pyrometer is immersed.

Absolute precision in the heating of articles inserted in this furnace is mechanically assured. The article is heated with uniformity in every part, without the possibility of a hot corner. The treatment for any particular description of steel having once been ascertained, may be repeated with certainty. Experiments carried out with this new furnace have demonstrated the fact that the hardening point is sharply defined, almost like the freezing point of water. Pieces heated to temperatures in the neighborhood of the critical point, and varying from each other by only 2 deg. Cent., are found after quenching to differ considerably in their physical properties, and it has been proved that the manner of quenching is of secondary importance. If the steel is heated to the exact point, as is possible with this furnace, it can be hardened satisfactorily in either cold or warm water or brine.

THE PRESENT STATUS OF ELECTRIC FURNACE WORKING.*

By CHARLES F. BURGESS, University of Wisconsin.

THE importance of any discovery is measured ultimately by the material benefits which are derived from it. Estimated upon this basis the electric furnace may not perhaps be assigned a degree of importance comparable to that claimed by various other electrical devices. There is little exaggeration in the assertion, however, that if electric furnace development continues during the next two decades at a rate approaching the progress made in the past ten years, it will have attained by that time a secure position among the most important of electrical appliances. To sum up the practical benefits, both immediate and remote, which it has already conferred would form the subject matter of an address much more pretentious than it is my purpose to undertake, yet it may be said to have only recently emerged from the experimental state.

The electrical furnace may be defined as a structure to which electrical energy is delivered for its conversion into thermal energy. Accepting this definition, the date of its invention goes back to the time when it was discovered that electricity passing through a conducting medium is converted into heat. It is therefore over a century old. Comparatively little attention was devoted to it, however, until twenty-five years ago, when Sir William Siemens devised and exhibited in operation his furnaces for the melting of platinum, iron, and other metals. So important an epoch did his work mark that Siemens is with justice called the father of the electric furnace industry. The usefulness which he ascribed to the electric furnace and the possibilities which he pointed out have been more than realized. Since then results of the greatest importance have been attained. Many of nature's most closely guarded secrets have been revealed; a new chemistry of high temperatures has been evolved; new ideas as to the constitution of matter have been developed; new methods of preparing known substances have been formulated; our stores of available materials have been enriched by the discovery of new compounds. Such are the results which have been accomplished through scientific research.

To attempt to define the status of the electric furnace from the standpoint of all interests would require a longer dissertation than is possible at this time, and it is proposed to limit the discussion to those features which are of especial interest to the electrical engineer.

The present status of the electric furnace may be summed up in the statement that it is to-day proving a most efficient weapon in the siege which man is laying to the secrets of nature; that some of the positions won by it have been occupied with great advantage, and that many more are capable of profitable occupation. It owes its importance, however, not so much to the wonders which it has wrought in the past as to the possibilities which it offers for the future. While it is only in process of emerging from the laboratory stage it has already reached the dignity of an agent whose services can be measured in terms of that sordid but universal unit, the dollar.

The electrical engineer is ever on the lookout for new worlds to conquer, and although aggression and conquest are his watchwords, he can well afford to stop and look back over what has been accomplished in electric furnace work. In so doing he will not only receive warning and encouragement, but he will discern many discoveries which the pure scientist has made, and which he, by applying his engineering knowledge, may make of material service to man. For it is true, that even if no new scientific discoveries should be made in the future, there yet remains a broad and fertile field in the development of those discoveries which have been made but not yet utilized.

In the high temperature produced in the electric furnace it has been shown that all substances can be melted. The oft encountered statement that lime, magnesia, molybdenum, tungsten, and the like, are infusible, is therefore incorrect, for not only can all known substances be melted, but they can be volatilized as well. These facts are full of significance and suggestion to the engineer. They not only show him that there are limitations upon the materials which he may use for furnace construction, introducing difficulties where the highest temperatures are to be developed, but it is possible that in the melting and fusion of materials they may undergo such transformation of their physical nature as to endow them with qualities of great value. One of the most successful industrial uses of the electric furnace is the fusion of aluminium oxide in the form of bauxite, resulting in the production of that physical form of the material designated by the trade name "alundum." This is a duplication of nature's process for producing corundum, but the artificial product has marked advantages over the natural material in the purity, cheapness, strength and toughness, which give it greater value for abrasive purposes.

The fusion of quartz has produced a valuable material for a new kind of glassware which is indestructible by rapid or extreme variations of temperature. Various refractory materials have their refractory qualities increased by melting and subsequent cooling. Experimental investigation in this direction has only begun, but the results already obtained point to many improvements which may be made in materials for furnace construction, materials resistant to chemical corrosion, and materials possessing high heat and electrical insulating properties. The volatilization of elements and compounds at high temperatures gives new methods for the purification and separation of materials, enabling the process of fractional distillation to be applied to all substances.

It has been shown that carbon is capable of conversion into its various forms, a fact industrially utilized with great advantage by the International Acheson Graphite Company in making graphite and graphitized electrodes from the ordinary forms of coal and coke. Moissan has demonstrated the possibility of changing carbon into the diamond, and has reproduced, artificially, all the variety of diamonds which nature furnishes, alike in all respects save size. It remains for the engineer to operate this process on a large scale to produce exact equivalents, and to duplicate not only the diamond but other gems.

All the oxides which had hitherto been regarded as irreducible have been reduced through the use of the electric furnace. Upon experiments which he has made, Borchers bases the claim that carbon is capable of taking the oxygen from any known compound at temperatures within the range of the electric furnace. Similarly, other reducing agents may be made effective, and the decomposition can be produced without any reducing agent whatever by utilizing the electrolytic action of the current. This has resulted in unlocking various of nature's stores, making available for man's use such materials as aluminium, magnesium, calcium, sodium, potassium, chromium, silicon, and many others which previously could be obtained only with great difficulty if at all.

The most important industrial application which has thus far been made of the reducing action is the production of aluminium, the cost of which within a comparatively few years has been reduced from $5 to about 30 cents per pound. The manufacture of magnesium and sodium are also industrial operations of importance. Other processes are in the state of industrial exploitation.

The march of improvement in this direction will necessitate further development in the method of operation, and particularly a more thorough investigation into the properties and uses of the materials which can be thus produced. It has been estimated that the earth's crust holds locked up in the form of oxides and similar compounds 27.2 per cent of silicon, 7.8 per cent aluminium, 5.5 per cent iron, 3.8 per cent calcium, 2.7 per cent magnesium, and various other substances, some of which are classed among the rare elements. One of the latest triumphs in the recovery of these materials is the production of metallic silicon by Mr. F. J. Tone, of Niagara Falls. This material is quoted in chemical lists at about 25 cents per gramme, but by this new process it can be profitably sold at 35 cents per pound. Though thus far only a few minor uses have been found for it, it is not unreasonable to suppose that a further knowledge of its properties will point to new needs and that this most abundant element may become also a most useful one. While the metallurgy of iron has been developed without the aid of the electric current, recent work has shown that the electric furnace will be able to play an important part in the future of this metal. Calcium, which can be obtained in the form of a pure carbonate at a cost of a fraction of a dollar per ton, has not yet yielded to the attack of the industrial electrometallurgist, though most promising laboratory results have been obtained, and the metal has recently been placed upon the market. When it becomes possible to obtain this metal for a few cents per pound, as will be the case beyond doubt, little effort will be required to build up a market for it since its known properties are such that it will enter the field of chemistry and metallurgy as a most powerful and advantageous reducing agent.

Magnesium, while very abundant in nature, sells for over two dollars per pound. Nearly all of this amount represents the cost of extraction, and, therefore, the possibility of a further improvement in the process is indicated. Its present cost is such as to limit its usefulness to a restricted field, but if this could be made comparable to the cost of aluminium, an analogy not impossible, it will become a metal of great service in the manufacture of alloys as well as for chemical and metallurgical purposes.

Moissan's classic researches show us that a large number of elements unite with carbon to form carbides, many of which were not known before the day of the electric furnace. Based upon this fact, though resulting from the independent discovery of the American inventor, Willson, the calcium carbide industry has been developed. This material was unknown a few years ago, but to-day thousands of tons are being produced annually. The reaction of this carbide with water forms that hydrocarbon, acetylene, which, although now finding its chief use as an illuminant, is capable of being transformed into other hydrocarbons. Manganese carbide reacts with water to form hydrogen and methane, thorium carbide gives ethylene, and cerium and uranium carbides yield liquid and solid hydrocarbons as well as the gaseous ones. Although the hydrocarbons other than acetylene have not been produced commercially, scientifically it is possible to produce petroleum and other like compounds. Such discoveries as these point to the great and significant fact that the whole field of organic chemistry offers itself as an incentive in the exploitation of the electric furnace.

Another class of carbides, such as those of silicon, boron, chromium, molybdenum, tungsten, and titanium are stable, not only resisting the attack of water but being extremely resistant to the most active chemical agents. The first of these, silicon carbide or carborundum, has found extensive application as an abrasive, and its use has led to the development of a new industry. Its extreme hardness, approaching that of the diamond, and the refractory nature of it and similar carbides, together with properties which may yet be discovered, point to the probability as well as the possibility that other carbides will have quite as extensive industrial application.

Moissan and his contemporaries have shown that silicon, boron, nitrogen, may be made to act like carbon in producing silicides, borides, and nitrides, each new compound having its own peculiar properties, and that the field may also be extended through the manufacture of the more complex compounds, such as the silico-borides, silico-carbides, boro-carbides, etc.

A contemplation of such possibilities is most bewildering, and to quote from an address by Prof. Joseph W. Richards referring to electrometallurgical progress, "We are so overwhelmed by new things of possible use to science or industry, that we can at most investigate only a small fraction of them. It is a virgin continent of undeveloped possibilities."

ADVANTAGES OF ELECTRIC FURNACE.

The electric furnace owes its place in the scientific and industrial world to certain characteristics which it possesses and to the advantages which it offers over other means of generating heat, the principal one being the high degree of temperature which is made available. An interesting comparison might be worked out showing that civilization progresses in a rate proportional to the utilization of heat energy in its highest degree of concentration. Each additional degree of temperature which can be produced and kept under control shows itself capable of new and useful purposes, and the electric furnace has added such an extension to the range of available temperatures that it has almost doubled that previously available.

It simply requires the passage of the electric current through a conducting medium to produce heat, the intensity of which depends upon the amount of current which passes. Inasmuch as most substances retain their conductivity at high temperatures, the degree of intensity which is theoretically possible is unlimited. Practically, however, limitations are placed upon it through the physical difficulties of keeping the conducting medium in place. While it retains its solid condition, the temperature is limited by the fusing point of the material; when fusion commences the difficulties of containing the melted material begin, and the temperature is limited by the point of vaporization. When volatilization begins, the gaseous materials escape from

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the field of action, carrying away the heat as rapidly as it is supplied to the furnace as latent heat of volatilization or as energy stored up as potential chemical energy. It is true that the temperature of volatilization might be increased by subjection to high pressure, but this involves construction of a container which can be made only of solid materials, having limitations imposed by the fusing temperatures. The electric arc maintained through a carbon vapor furnishes perhaps the highest degree of temperature attainable, the temperature of which is usually considered as being definitely fixed by the volatilization of carbon. Through limitations upon our methods of measuring these high temperatures the exact value to be assigned to the temperature of the electric arc cannot be stated, though the most satisfactory measurements give values ranging between 3,600 deg. and 4,000 deg. C. Whether this is the ultimate limit to be attained by electrical means is difficult to say. There is, of course, the possibility of exceeding it by maintaining the arc under a high atmospheric pressure, or by feeding electrical energy to the arc more rapidly than it can be dissipated by the volatilization of carbon, or in other words, superheating the carbon vapor. Such speculation, however, is not necessary to show that the electric furnace has unbounded possibilities, since the range of temperatures below that of the ordinary arc offers an unlimited field for usefulness.

The maximum temperature which may be obtained theoretically by the combustion of carbon in oxygen is higher than that which has been attained in the electric furnace, but practical conditions place a greater restriction upon it. At high temperatures carbon cannot be consumed to CO_2, but rather to CO, and this gaseous product escapes rapidly and carries the heat away from the furnace. Further, it is impossible under practical conditions to supply pure oxygen, and in utilizing the atmospheric supply not only must the large quantity of accompanying nitrogen be heated, but the excess of air which must always be supplied also carries away a large amount of heat. The maximum temperature which has been attainable in the combustion of fuel in the gaseous, solid or liquid form, from which volatile products of combustion are formed, probably does not exceed 2,000 deg. C., and even this value can be obtained only at a low efficiency, and under most favorable conditions for the conservation of heat.

Since the introduction of the electric furnace, other new methods have been worked out for obtaining the higher temperatures. One of these is known as the thermit method, in which aluminium is the fuel consumed, the product of combustion being aluminium oxide, which is not volatile at the high temperatures, and therefore does not carry away the heat. By this means temperatures considerably exceeding 3,000 deg. can be readily attained. Calcium, magnesium, and certain other electropositive elements may be similarly utilized for attaining high temperatures, but the electric furnace stands alone as a means of producing these temperatures economically. The great advantage of electric heating is that it is not necessarily associated with products of combustion and does not need for its production a consumption of materials. In other words it gives "pure, unadulterated heat." Therefore, for temperatures exceeding 2,000 deg. the electric furnace, if not the only means, is the most economical one to be employed.

Another advantage which the electric furnace has over combustion furnaces is that a great amount of heat can be developed in a compact and limited space and that the same degree of temperature can be attained whether the furnace is operated on a laboratory or on an industrial scale.

From the standpoint of refractory materials the electric furnace represents a distinct gain. The temperature at which ordinary crucible or muffle furnaces can be operated is limited by the resistance which available refractory materials offer to melting, and to the corrosive and fluxing action of materials to which it must be exposed. The same refractory materials may be used for higher electric furnace temperatures since the materials to be heated, as well as the source of heat, are within the refractory walls. Where the heat has to be transmitted through such walls in other forms of furnaces the material to receive the heat cannot receive so high a temperature. Further than this, the refractory walls of the electric furnace can be kept cool by artificial means such as an air blast or water circulation, and a still more advantageous property is that the material undergoing treatment may itself constitute the walls of the furnace. This advantage of interior heating is utilized in the production of phosphorus and carbon bisulphide, most of which is now produced in the electric furnace, the greater cost of electrical heating being more than compensated by the saving in crucibles and retorts, the destruction of which constituted large items under the older methods.

In the matter of control of heat, the electric furnace stands by itself, for the rapidity of heating, duration of heating, and adjustment of the temperature are under the full and exact control of the operator.

Fusions can be carried out under oxidation or reducing conditions, for the construction of the furnaces makes it very easy to operate in an atmosphere of any gas desired. Higher purity can thus be attained.

The final advantage, which is really a summary of all the others, is economy of operation. The economy of the electric furnace as compared with that of other furnaces requires the balancing of electrical energy against energy obtained from the combustion of fuel; cost of installation and maintenance of the equipment, amount of labor, value of product, danger to operatives. A careful weighing of these factors in a considerable number of metallurgical and chemical operations on an industrial scale has shown the resultant advantage to lie with the electric furnace.

VARIOUS FORMS OF FURNACES.

A considerable variety of expression is found in the classifications of electric furnaces by different authorities. It is common to classify them as follows:

Arc furnaces, in which the material is heated by an arc, usually established between carbon electrodes.

Resistance furnaces, in which the heat is developed by the passage of current through a solid conducting medium.

Electrolytic furnaces, in which heat is generated by the passage of current through a fused mass, and in which at the same time the material is decomposed by the electrolytic effect of the current.

Since in all of these classes the current flows through a conducting medium and therefore encounters a "resistance" it is not logical to employ the term resistance furnace to designate any one of them. A more satisfactory classification would be in accordance with the character of the medium which constitutes the conductor. This gives three classes:

1. Furnace in which the heat is developed by the passage of current through a solid conducting medium or "resistor."
   a. The conducting medium, or core, may consist of the material which is to undergo useful transformation.
   b. The heat is developed in a core of conducting material, and this heat is in turn communicated to surrounding material constituting the charge, either with or without the interposition of a wall separating the two materials.
2. Furnace in which the heat is developed by the passage of current through a liquid conducting medium.
   a. Electrolytic.
   b. Non-electrolytic.
3. Furnace in which the heat is developed by passage of current through a gaseous conducting medium.
   a. Arc furnaces.
      Where arc plays between two or more carbon electrodes in the neighborhood of material to be heated.
      Where arc is maintained between one carbon electrode and another electrode of the material to be heated.
   b. High tension furnaces.
      Where arc or high tension discharge plays between two electrodes in a gaseous medium for the production of chemical change in such medium.

(To be concluded.)

THE CHEMICAL FERTILIZATION OF SEA-URCHINS' EGGS.*

By JACQUES LOEB.

IN a series of papers I have described a method by which it is possible to produce swimming larvæ from the unfertilized egg of the sea-urchin. This method consists in putting the sea-urchins' eggs for about two hours into sea-water whose concentration is raised by the addition of about 15 cubic centimeters $2\frac{1}{2}N$ NaCl to 100 cubic centimeters of sea-water. The development of these eggs, however, differs in four essential points from that of the eggs fertilized with sperm. In the first place, the eggs fertilized with sperm form a characteristic membrane as soon as the spermatozoon has entered, while the unfertilized eggs treated with hypertonic sea-water develop without the formation of a membrane. Second, the rate of development is considerably faster in the fertilized egg than in the egg caused to develop parthenogenetically. Third, the larvae originating from fertilized eggs rise to the surface of the water as soon as they begin to swim, while those originating by the above mentioned osmotic process swim at the bottom of the dish. Fourth, the number of larvae developing from fertilized eggs is, as a rule, practically a hundred per cent, while in the case of artificial parthenogenesis a much smaller percentage of the eggs develop into swimming larvae. In the case of Arbacia I often succeeded in causing more than twenty per cent of the unfertilized eggs to develop, but in the case of Strongylocentrotus—the form of the sea-urchin common at Pacific Grove—I was rarely able to obtain even as high a percentage of developing eggs. Often enough only a fraction of one per cent of the eggs yielded swimming larvae by the osmotic method of artificial parthenogenesis.

In thinking over the possible cause of this difference between the development of the egg fertilized by sperm and of the egg caused to develop by osmotic influences, it occurred to me that the spermatozoon might carry into the egg not one, but several, substances or conditions, each of which was responsible for only a part of the specific features of sexual fertilization; and that in order to completely imitate the action of the spermatozoon it might be necessary to combine two methods of artificial parthenogenesis, each of which alone imitated the process of sexual fertilization only partially. This latter idea proved correct far beyond my expectations.

In looking for substances which might be utilized for bringing about artificial parthenogenesis I tested the effects of ethylacetate, an ester, which had shown itself so effective in experiments on the control of the heliotropic reactions of fresh-water Crustaceans, recently published in this Bulletin. I found that if the unfertilized eggs of Strongylocentrotus are brought into 50 cubic centimeters of sea-water, to which about 0.6 cubic centimeter of a grammolecular solution of ethylacetate is added, and left in this water for from two to four minutes, they not only form a membrane† when put back into normal sea-water, but begin also to segment. At a temperature of about 19 deg. or 20 deg. C. they begin to divide into two cells, about five or six hours after the treatment with ethylacetate, and later they may divide into more cells. In about twenty-four hours, however, all the eggs disintegrate, and I have never seen an egg which had been thus treated reach the blastula stage.

If the eggs are left in the mixture of ethylacetate and sea-water they neither form a membrane nor do they segment.

On the other hand, the application of my old method of artificial parthenogenesis gave me this year poor results, owing possibly to the fact that the breeding season of Strongylocentrotus is just beginning. I succeeded in causing only a fraction of one per cent of the unfertilized eggs treated with hypertonic sea-water (100 cubic centimeters sea-water plus 15 cubic centimeters $2\frac{1}{2}N$ NaCl) to develop into swimming larvae; and even these larvae, as a rule, died in an early larval period.

When I applied both methods in succession, however, namely, the original osmotic method and the treatment with ethylacetate, I obtained surprising results. Instead of a fraction of one per cent of the eggs developing, I had it in my power to cause ninety to one hundred per cent of the eggs to develop. All the eggs formed the membrane which is characteristic of the egg fertilized with sperm. The rate of segmentation was practically the same as that of the eggs of the same female, fertilized with sperm. A large percentage of the blastulae originating from this combination of methods looked perfectly normal, and rose to the surface of the sea-water. Their further development into gastrulae and plutei occurred with the same velocity as that of the control eggs, which had been fertilized by sperm; and the larvae showed an equal degree of vitality.

The order in which these two methods, namely, that of treating the eggs with ethylacetate and with hypertonic sea-water, were applied was not immaterial. The results were much better when the eggs were first submitted to the hypertonic sea-water, and afterward to the ethylacetate, than if the order was reversed. The usual procedure was to put the unfertilized eggs for about two hours and twenty minutes into a mixture of 100 cubic centimeters sea-water and 15 cubic centimeters N NaCl at a temperature of about 19 or 20 deg. C. The eggs were then put into normal sea-water, where they were left for about five or ten minutes, and then put into another dish with 50 cubic centimeters sea-water. Then 0.6 cubic centimeter of a grammolecular solution of ethylacetate was added in drops and the whole stirred with a pipette, so as to bring about a rapid and thorough mixture of the ethylacetate and the sea-water, and to expose the eggs to the diluted ethylacetate.

From time to time a few drops containing eggs were put into a watch glass containing about 10 cubic centimeters of pure sea-water, in order to ascertain whether the eggs were ready to throw out the membrane. As soon as the eggs formed the membrane when put into normal sea-water, they were transferred from the ethylacetate solution into normal sea-water. This was usually the case in from two to four minutes after the eggs had been put into the ethylacetate solution.

When the eggs were taken out a little too early—namely, at a time when only a number, but not all, of the eggs formed a membrane—it was found as a rule that only such eggs showed a normal and rapid segmentation as had formed a membrane. The other eggs, as a rule, did not segment at all, or if they segmented, which occurred only exceptionally, they segmented at the slow rate of the eggs treated only with hypertonic sea-water. The fact that in such cases only those eggs developed which had formed a membrane is another coincidence between this new method of artificial parthenogenesis and sexual fertilization.

It is thus obvious that we are now able to imitate the process of sexual fertilization in the egg of the sea-urchin completely and in all its essential features by purely physical and chemical means. The fact that a number of the parthenogenetic larvae raised by the new method seem to have the same vitality as the larvae produced by normal fertilization arouses the hope that it will now be possible to undertake the solution of the various problems for which the raising of parthenogenetic larvae in large numbers is a prerequisite.

AFRICAN PYGMIES.

THE well-known explorer, Col. Harrison, is returning to England after his latest expedition to Central Africa. He is accompanied by six pygmies from the Ituri or Stanley Forest of the Congo Free State. Four of the pygmies are men and two are women, and all are between eighteen and thirty-four years of age. Their heights vary from 3 feet 8 inches to 4 feet 6 inches. They are visiting London of their own free will, Col.

* From the Rudolph Spreckels Physiological Laboratory of the University of California.

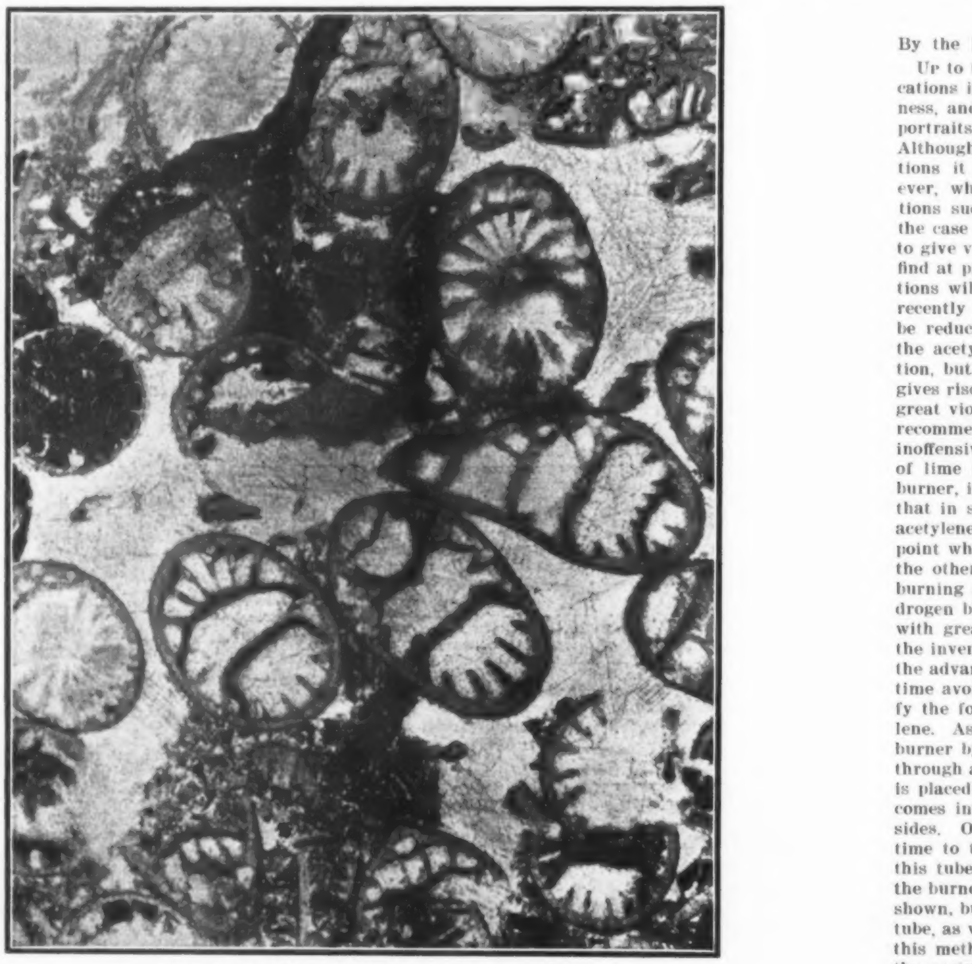
† The formation of a membrane in unfertilized eggs has already been observed by former experimenters. In 1887 O. and R. Hertwig noticed that the unfertilized eggs of a sea-urchin formed a membrane when put into sea-water to which chloroform had been added. Herbst noticed in 1892 that a number of substances, such as xylol, toluol, benzol, act in the same way. More recently he has obtained similar results with silver salts. (Herbst, Mittheilungen aus der zoologischen Station zu Neapel. Vol. 16, p. 445, 1904.)

Harrison having promised to send them back if they wish it. The explorer found that the pygmies are still fairly numerous, and live on the outskirts of the great forest, rarely penetrating it except for purposes of concealment. The Colonel found them quite friendly when he had once gained their confidence. They are of a warlike disposition, and dwell in small villages, each of which has its own chief. Their houses consist of erections of sticks covered with leaves. The pygmies naturally are sparsely clad. Some of them have hair on the breast and legs, but the large majority are free from it. The maximum age they attain is forty years. The majority are intelligent and fairly good-looking. The distinguishing features are thick lips and noses, while their complexion is sallow.

During his expedition in the pygmies' home Col. Harrison spent three weeks with them hunting okapi, but owing to the denseness of the forest it was impossible to shoot any specimens of the rare animal. Two skins, however, were procured from the natives, but both were in a badly mutilated condition. Even in the forest the okapi is now becoming rare. The explorer, however, has succeeded in bringing back with him a small black-haired monkey of an exceedingly rare type, called the colopus. Col. Harrison followed the Nile down to the equator, covering in all 1,000 miles, and at one time traveled 138 miles in less than five days.

MICROPHOTOGRAPH OF FOSSIL COAL.

MR. THOMAS E. FRESHWATER won a silver medal at the Louisiana Purchase Exposition for the accompanying microphotograph of fossil coal, which is reproduced from Knowledge and Scientific News. The coal of which this is a photograph occurs at Beith, Scotland.



MICROPHOTOGRAPH OF FOSSIL COAL.

RADIUM TESTING.

By F. H. GLEW.

IN testing the commercial value of radium by means of the electroscope, it is important that a full knowledge of the various steps involved should be obtained. I therefore propose to consider more closely the properties of the various rays under consideration, and point out the reasons for certain modes of procedure.

In the first place, it is out of the question to measure the total radiant energy, because all radium salts are sold so inclosed that about 99 per cent of the total energy cannot escape from the containing vessel, which is usually made of glass or mica. Both of these substances cut off every trace of the gaseous radio-active emanation. The *Alpha* rays, too, are entirely cut off by the glass, and only the merest trace, if any, can pass through the very thin mica window of the ebonite capsules; therefore in practice we are not concerned with these two forms of emission, but are simply concerned with the *Beta* and *Gamma* rays, which, together, constitute the remaining one per cent of the total radiant energy.

It is a singular fact that the therapeutic success already obtained has been the result of this one per cent only; it is with this relatively small proportion that the luminous screen effects, the photographic effects, and electrical properties are demonstrated.

The electroscope does not measure the *Beta* and *Gamma* rays directly; what we measure with it is the ionization of the air produced by these rays. In some way these rays, in passing through any gas, so agitate, or shatter, its molecules, either by simple impact of the projected negative corpuscles, or electrons, which constitute the *Beta* rays, or by sustained agitation resulting from the neutral *Gamma* rays, which are probably ethereal disturbances, that it is capable of conducting electricity. When any gas, which is ordinarily a very poor conductor of electricity, is ionized, it is at once a very good conductor; and so the charge on the electroscope, whether positive or negative, can leak away in proportion to the rays producing this condition. It is most important to bear in mind that ionization, however produced, does not cease to exist instantaneously. This peculiar condition lasts for a fraction of a second—long enough for the ionized molecules to be blown a few inches.

This temporary persistence of ionization can be well shown as a lecture experiment (see diagram) by placing a tube of radium inside a thick lead pipe, about two feet long, which has been S-shaped, so that practically all the straight line radiation is cut off. If the other end of the pipe is placed near the electroscope there is no discharge, but if the mouth is placed near the end containing the radium a puff of breath through the pipe will blow the already ionized air surrounding the radium through the bent tube, and in this way inclose the ionized air in the immediate vicinity of the sample.

the charge can be blown off the electroscope like blowing a candle out. It is as well to first blow air through when the radium is not within the pipe, to show that there is no effect without the radium.

It will now be seen that drafts in the testing-room should be avoided as much as possible, for the radioactivity readings may be higher if the air movement takes place from the specimen being tested toward the instrument, and it is possible for the reverse motion to give a reading which is too low. This error can be entirely eliminated by letting the distance be fairly great—it is not likely to influence the result, in any ordinary room, at the selected standard distance of three feet.

Red-hot bodies also have the power of producing ionization, but this effect is only produced in their immediate vicinity. However, the air, thus rendered conducting, can be moved over a considerable distance, and so cause error. For this reason any flame should be remote, and smoking forbidden near the electroscope.

Samples should be placed on an equality as much as possible; therefore it is well to allow for differences in thickness of the glass tubes by inclosing all specimens in another receptacle, through which only penetrating rays can pass. If a tin box is used this condition is insured, and the conditions may be regarded as uniform throughout. The lid should be placed on the box to inclose the ionized air in the immediate vicinity of the sample.

To show the reliability of this method, I may mention the result of a recent test of a glass tube of radium bromide, said to be pure, containing 10 milligrammes, for which a large sum had been paid. The electroscopic needle fell in 313 seconds with the standard specimen tube containing 5 milligrammes, but the specimen to be tested required 1,125 seconds, whereas if it had contained 10 milligrammes of pure bromide it should have discharged the instrument in half the time of the 5-milligramme tube; therefore,

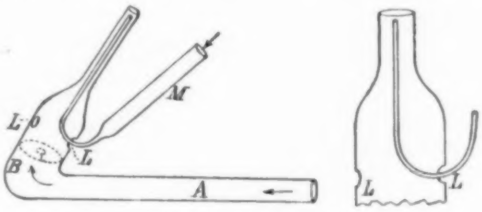
$$\frac{313 \times 5}{1,125} = 1.39 \text{ milligrammes.}$$

The radio-activity of the specimen was only equal to 1.39 milligrammes of pure bromide. The vendor insisted it was pure bromide, and disputed my test. This sample was then tested by Sir William Ramsay, who wrote under my certificate confirming it. His actual figures were 1.33 milligrammes.—The Pharmaceutical Journal.

OXY-ACETYLENE LAMP.

By the Paris Correspondent of SCIENTIFIC AMERICAN.

UP to the present, acetylene has found but few applications in photography, but its actinic qualities, cheapness, and ease of production recommend it for taking portraits, and it is only surpassed by the voltaic arc. Although it may not be sufficient for lantern projections it answers very well for enlargements. However, while acetylene is not well adapted for projections such as needed for lectures in a large hall, in the case of projections at shorter distances it is found to give very good results. The lack of power which we find at present in the case of acetylene for long projections will no longer be an objection if the new device recently brought out by M. Graverend, of Paris, can be reduced to a practical form. It is desired to mix the acetylene with oxygen to obtain a better combustion, but this presents a great disadvantage in that it gives rise to an explosive mixture which detonates with great violence. This combination cannot, therefore, be recommended unless some method is found to make it inoffensive. M. Graverend first tried to heat up a piece of lime in a jet of acetylene coming from a Bunsen burner, in which the gas is mixed with air. He found that in spite of the very high heat of combustion the acetylene cannot bring the lime up to the required point where it will give off a brilliant white light. On the other hand it is impossible to use the method of burning acetylene and oxygen in the ordinary oxy-hydrogen blowpipe, as this might give rise to explosions, with great danger to life. After some trial, however, the inventor succeeded in finding a method of utilizing the advantages of the gaseous mixture and at the same time avoiding accidents. It is only necessary to modify the form of the Bunsen burner for use with acetylene. As the diagram shows, the gas is brought to the burner by the tube, *A*, and passes into the upper part through a very small opening, *B*, in a diaphragm which is placed here. At this point it mixes with air which comes into the burner through the holes, *L L*, in the sides. One of these holes gives passage at the same time to the oxygen supply tube, *M*. The diameter of this tube is reduced to 0.08 inch where it passes into the burner. This tube ends at the top of the burner, as shown, but does not reach quite to the end of the main tube, as will be observed in the detail on the right. By this method we avoid all accidents from explosion, as the acetylene passes through a hole which is only 0.1 millimeter (0.04 inch) in diameter, and therefore the return of the flame is not to be feared, according to Le Chatelier's principle that none of the combustible mixtures of acetylene and oxygen will allow of propagating a flame in a tube of 0.5 millimeter (0.02 inch), and in tubes of 1 millimeter only the most combustible mixtures will effect this. The supply of the acetylene generator should be regulated so as to feed a Bunsen burner of 20 liters per hour (0.7 cubic foot). The oxygen reservoir should give a somewhat smaller quantity, half or three-quarters of this amount. With the new "oxylith" apparatus of M. Jaubert, in which the oxygen is formed by the action of water upon pieces of oxylith (oxides of sodium), the production of the gas can be regulated as easily as with acetylene, and the supply



OXY-ACETYLENE LAMP.

is quite regular. The oxygen and acetylene apparatus can be set working within a few minutes, giving a constant production, and occupy but a small space, being easily portable as well as cheap. Therefore we see the advantages which the new method offers, and another point is the absence of a hissing noise. The use of the orifices in the burner which allow air to enter are not absolutely indispensable, but as these already exist in all Bunsen burners it has been found advisable to keep them, so as to avoid the extinction of the acetylene flame, and at the same time a certain economy in oxygen consumption can be realized. The method brought out by M. Graverend has proved to be successful in the laboratory, and it only remains to adapt it in a commercial working device.

FIG. 1.—THERIDION AND ITS CAPTURING THREADS. BELOW: AN ANT-LION AND ITS PITFALL.

THE ENEMIES OF ANTS.

BESIDES man, who has declared war to extermination upon them, and who nevertheless succeeds but imperfectly in his work of destruction, ants have more enemies than the luxuriance of their colonies and the abundance of the individuals would lead us to believe. But their fecundity is so great that the disappearance of a few of them passes unnoticed, and that the decimated battalions are able immediately to form again in larger numbers than before. As for their enemies, they are of a very diversified nature. From a learned paper by M. Charles Janet upon the subject of these insects are gleaned the following particulars:

The length and frequency of ant excursions expose the insects to the danger of tumbling into the pitfalls excavated in the sand by the larvæ of the ant-lion, of being seized by the larvæ of tiger-beetles (*Cicindelidæ*) concealed in vertical holes, and of becoming glued by the antennæ to the capturing threads that certain sedentary spiders, such as that called *Theridion viparium*, attach to the ground. This spider, in fact, establishes itself in places frequented by ants, and captures the latter for food. It forms its nest at the lower part of bushes an inch or so above the ground, after constructing an irregular network. From this latter it suspends by its point a sort of elongated cornet from ½ to ¾ of an inch in length, and ½ an inch in width at the mouth, formed for the most part of particles of earth. The Theridion descends by a thread, selects and grasps a particle of earth with its fore legs, surrounds it with a few threads by means of its hind legs, and, holding it with the latter, attaches it to the edge of the mouth of the cornet. Numerous guy-threads connect this edifice with surrounding objects and render it stable. From this structure start a certain number of capturing threads, which, running obliquely, are attached by the ends to the ground.

When an ant walking under the nest happens to pass near one of these threads and touch it with its antennæ, the latter become firmly glued thereto. The insect, then becoming furious, detaches the thread from the ground in its struggles, and recedes to as great a distance as the elasticity of the thread permits; while the tautened thread, forming a spring, abruptly pulls the prisoner back as soon as the latter loses a firm hold upon the ground. The spider, notified of the capture by the shocks imparted to its nest, immediately leaves the latter, and, running to the thread, gives it a vigorous pull with its forelegs. If the ant again loses its hold upon the ground, it is hoisted into the air like a pail at the end of a rope. If, on the contrary, favorable circumstances permit it to remain firmly fixed to the ground, it will be impossible for the spider to haul it up. In such an event, it descends to the ant, turns its abdomen upward, and, while holding on to the thread with its forelegs, pulls a glutinous thread from its spinneret with its hind ones and encircles the struggling victim therewith. The latter soon loses its hold, and its captor, apprised by the relaxing of the thread, runs quickly upward, carrying along its prey, by means of its hind legs, to the web that surrounds the mouth of the cornet. Here, by means of its hind legs, it continues to involve the ant in a network of threads. After the victim is sufficiently enveloped, its captor bites either one of its legs or antennæ, and then goes away and waits until death shall supervene through the action of the poison that it has injected from the orifice near the point of its fangs. The victim struggles and does not die until after suffering long agony. The ants thus captured are stored up in the cornet, which the spider uses as a place of refuge. This same cornet serves also as a shelter for the eggs, and, later on, for the young that are hatched therefrom. These latter also feed upon the ants captured by the mother. They are able, moreover, to take part in the capture. There is another species of spider also that feasts upon ants, and that is the *Zodarion elegans*. This spider constructs neither net nor web for capturing its prey, but, at the hours for hunting, prowls around formicaries, and, approaching processions of ants, suddenly seizes such individuals as are weak, wounded, or impeded by too heavy a burden. After the spider has seized its prey, it carries it away to its abode, which is always surrounded with debris that leave no doubt as to the nature of its food.

At the time of their sorties, and particularly when they are absorbed in the heat of a battle, ants are exposed to the attack of certain Hymenopters, say the *Elasmosma berolinense*, which fastens itself to their abdomen, unsheaths its ovipositor, and deposits its eggs in the interior of their body. The larvæ, too, of ants are selected by certain entomophagous Hymenopters as receptacles for their eggs, the larvæ from which develop at the expense of the tissues of their victim, and undergo their nymphosis in the cocoon of the ant. The difficulty that the entomophagous Hymenopters meet with in entering the nests explains why the larvæ of ants are not victims of a larger number of them.

Sleep, which is very necessary to animals expending so much energy, and the nocturnal torpor occasioned by cold put ants at the mercy of certain myrmecophagous Coleopters, among which may be mentioned the *Myrmoecia fussi*. This insect remains in the least frequented parts of natural nests, and, in artificial ones, keeps itself concealed as much as possible. The ants attack it when they meet it, the workers directing their abdominal extremities against it, and the queens biting it with their mandibles. Such ill treatment forces it to fly to another place of concealment, near which are afterward to be found the remains of the ants that it has eaten during the night. Its brilliant black color and its size, which is between that of the laborers and that of the queens, render its distinguishment in the nests quite difficult.

The large number of individuals, and the almost incessant renewal of the progeniture, which contribute very much toward the power of ants, is the cause, on the other hand, of their becoming an always easily found prey for other animals that are individually stronger than they, or that are so organized as not to have to suffer from their means of defense. Thus it is that a very large number of these insects is destroyed by the tamanduas and orycteropes, and certain birds, such as the green woodpecker and yellow pheasant, and certain batrachians, such as the toad. It is also the large number of individuals and the incessant excursions of certain species which frequently set out from their nest, and often travel in long processions, that permit a certain number of predatory Hymenopters to furnish their progeny with ants as food. Such is the case with the *Fertonius luteicollis*, a fossorial insect, which excavates cells, grouped without order, to a slight depth in sandy ground. It hunts an ant which is very common in the vicinity of Algiers, and which constructs roads and travels over them in long processions. The *Fertonius* hovers at a height of a few fractions of an inch over these roads, selects a victim from the most corpulent of the ants, follows it for a few instants, and then swoops down upon it, seizes it and carries it off; and, doubtless in order to be able to sting it at its ease, generally alights at a short distance from the road. The hunter is not successful every time, and often has to pursue several ants before being able to seize a single one of them; but it manages nevertheless to fill about one cell a day. Into this it compresses about forty ants; and in the interior of the mass deposits a curved white egg, which it glues transversely upon the thorax of the ants against the first pair of legs. The ants thus stored up are not killed, and their antennæ and mouth parts are in continuous motion; but, in consequence of the sting of the captor, their legs are paralyzed to such a degree as to be useless, and their abdomen, which is armed with a formidable poison apparatus, is rendered entirely immovable. The egg is hatched at the end of about two days. The larva, which is provided with mandibles in the form of fangs, feeds upon the ants, which four or five days after their capture have become inert and immovable. After it has reached the end of its development, it spins a cocoon, which it attaches by its cephalic extremity to the wall of the cell, and which remains surrounded by the debris of the ants. A certain number of these debris furnish the necessary points of attachment for the beginning of the spinning of the cocoon, and remain adherent to the external surface of the latter.

Finally, the abundant progeny found in the nests of ants constitutes a choice prey for any animal that is capable of making off with it. This is something that is done by the ants themselves, which engage in fierce battles with each other for the sake of capturing nymphs, and also, almost with impunity (on account of its small size) by the *Solenopsis fugax*, which enters the formicaries of other species in order to prey upon the larvæ contained therein.—Translated from La Nature for the SCIENTIFIC AMERICAN SUPPLEMENT.

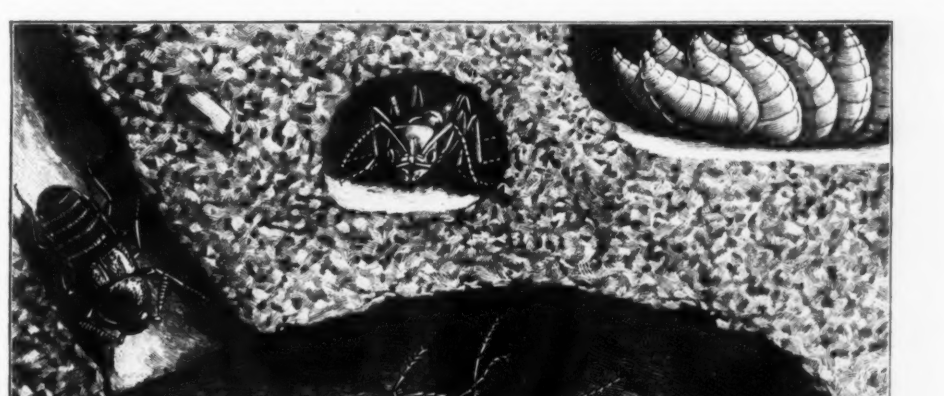


FIG. 2.—TWO MYRMŒCIÆ FUSSI PREYING UPON AN ANT.

COPPER AS AN ALGICIDE AND DISINFECTANT IN WATER SUPPLIES.*

By KARL F. KELLERMAN.

AT the time of publication of the results of the experimental use of copper sulphate as an algicide and disinfectant in polluted water,[1] definite recommendations concerning the proposed method of treatment were avoided. This was done both to check those who through ignorance or excess of zeal might be led to unnecessary or extravagant applications of the treatment and to gain the additional information of a season's experience by maintaining supervision over treated supplies. The work can no longer be considered in an experimental stage, however, and the present need is not an exposition or explanation of the method but a discussion of actual experience, which, by setting forth the conditions presented, the difficulties encountered, and the success attained, may serve as a guide to the water engineer and to those who find it necessary to use copper in dealing with contaminated supplies. An attempt is therefore made to arrange and correlate the results of laboratory work and practical applications of the method, with a view to facilitating the comprehension of the various ideas involved in the abundant results that the work has yielded. Moreover, it is apparent that the prejudice against using copper in drinking water is still great in many quarters, and some pains have been taken to ascertain whether there exist sufficient grounds for this hostility.

DIFFERENCE IN TOXICITY OF COPPER SULPHATE IN LABORATORY AND FIELD CONDITIONS.

The treating of various reservoirs has brought to light an interesting fact.

The concentration necessary to kill algæ in the laboratory is from five to twenty times as great as that necessary to destroy the same species in its natural habitat. The reason for this is difficult to demonstrate. It is not due to difference of light and temperature, nor to the greater proportion of the treated water to the mass of algæ so often found in reservoirs. The most probable explanation is that under normal conditions the rapid growth of the organism is favored with a consequent maintenance of the highest degree of sensitiveness to adverse conditions. When algæ are brought into the laboratory, the change in environment and the injury from handling allows only the more resistant individuals to persist, and the forms developing from these are, therefore, harder to destroy than are those of the same species growing in nature.

In view of this fact the quantities of copper sulphate which are required to destroy the different polluting forms are much less than those formerly considered necessary. Many of the concentrations in the following revised table have been obtained by actual use in reservoirs under natural conditions. The remainder have been determined by analogy, and only on theoretical grounds can they be presumed to be correct.

It will be seen that there is absolutely no possibility of correlating the effects of copper upon related forms with the idea of formulating a rule for general use. Even species of the same genus often show a greater variation in their susceptibility to copper than is found in widely separated genera, and the necessity of knowing the specific form causing the difficulty becomes more and more evident as experience with the effect of copper upon algæ is accumulated.

Number of Parts of Water to One Part of Copper Sulphate in Dilutions Recommended for Destroying Different Forms of Algæ.

Water of average hardness and at a temperature of about 15° C. (59° F.)

Aphanizomenon	5,000,000
Anabaena circinalis	10,000,000
Anabaena flos-aquae	10,000,000
Asterionella	8,000,000
Beggiatoa	100,000
Cladophora	1,000,000
Chlamydomonas	1,000,000
Clathrocystis	8,000,000
Closterium	6,000,000
Coelosphaerium	3,000,000
Conferva bombycinum	3,000,000
Crenothrix	1,000,000
Desmidium	450,000
Draparnaldia	3,000,000
Eudorina	100,000
Euglena	1,500,000
Fragilaria	4,000,000
Glenodinium	2,000,000
Hydrodictyon	10,000,000
Mallomonas	500,000
Microcystis	1,000,000
Navicula	15,000,000
Nitella	10,000,000
Oscillatoria	5,000,000
Palmella	500,000
Pandorina	100,000
Peridinium	450,000
Raphidium	300,000
Scenedesmus	1,000,000
Spirogyra	25,000,000
Stigeoclonium	3,000,000
Stephanodiscus	250,000
Synedra	600,000
Synura	3,000,000
Tabellaria	600,000
Ulothrix	5,000,000
Uroglena	20,000,000
Volvox	4,000,000
Zygnema	2,000,000

Salt Water Forms.

Cladophora	5,000,000
Enteromorpha	10,000,000
Ulva	5,000,000

EFFECT OF COPPER SULPHATE UPON FISH.

The effect of copper sulphate upon different species of fish demands more attention than was formerly supposed. The treating of a small trout pond in Massachusetts resulted disastrously to about 40 per cent of the 8-inch trout with which the pond was stocked, and emphasized the fact that all game fish are not equally resistant to the effect of copper. A series of investigations[2] has shown that the brook trout is more sensitive than any other fish yet tested. In some cases 1 part of copper sulphate to 7,000,000 parts of water is the maximum strength that can be endured by trout under 5 inches in length. Larger ones, as a rule, will endure but a slightly stronger solution, though the treatment of one reservoir was reported in which a solution of 1 to 1,000,000 was used without injury to trout or other fishes. Here, however, the immunity was probably due to the rapid precipitation of the copper by organic matter or alkalis[3] and not to the resistant condition of the fish. Reference to the reports of reservoirs treated, notably those of Butte, Mont., Cambridge, N. J., and Hanover, N. H., shows that fish are uninjured at concentrations ordinarily used and their presence is no obstacle to successful treatment.

Below are given the maximum amounts of copper sulphate which, judging from a very limited number of experiments, should be used in water containing fish of certain species. It is hoped that work planned in connection with the Bureau of Fisheries will make possible a fuller report upon this phase of the subject.

Number of Parts of Water to One Part of Copper Sulphate in Dilutions Which Will Not Injure Fish of Certain Species.

Trout	7,000,000
Goldfish	2,000,000
Sunfish	750,000
Perch	1,500,000
Catfish	2,500,000
Suckers	3,000,000
Black Bass	500,000
Carp	3,000,000

Experiments of the United States Commission of Fish and Fisheries[4] show that 1 part of copper sulphate to 582,000 parts of water will kill quinnat salmon in a few hours; this suggests that this fish is very sensitive, probably being killed at concentrations between those fatal for trout and those fatal for carp.

CONDITIONS DETERMINING THE PROPER QUANTITY OF COPPER SULPHATE FOR ERADICATING ALGÆ.

The importance of knowing the temperature of the contaminated water is second only to the necessity of knowing the organism present. With increase in temperature the toxicity of a given dilution increases, and *vice versa*. Assuming that 15 deg. C. (59 deg. F.) is the average temperature of reservoirs during the seasons when treatment is demanded, the quantity of copper should be increased or decreased approximately 2.5 per cent for each degree below or above 15 deg. C. It is probable that the influence of temperature could be better expressed by geometrical than by arithmetical progression, but the accurate determination of this point can be made only after experiments have been recorded in various localities under different conditions for a number of years.

Similar scales should be arranged for the organic content and the temporary hardness of the water. With the limited data at hand it is impracticable to determine these figures, but an increase of 2 per cent in the quantity of copper for each part per 100,000 of organic matter and an increase of 0.5 to 5 per cent in the proportion of copper for each part per 100,000 of temporary hardness will possibly be found correct. The proper variation in the increase due to hardness will depend upon the amount of dissolved carbon dioxid; if very small, 5 per cent increase is desirable; if large, 0.5 per cent is sufficient.

APPEARANCE OF RESISTANT FORMS OF ALGÆ IN RESERVOIRS PREVIOUSLY TREATED.

Since adding copper to a reservoir destroys only the polluting organisms then present in the water, it is possible that other forms, the resting spores of which are buried in the mud, may develop after treatment and occasion a second pollution. There is thus the probability that some reservoirs will be cleansed of Anabaena or Oscillatoria or some such polluting species only to allow a subsequent development of forms more or less resistant to copper, such as some of the desmids. It is improbable that these organisms, or any of the algæ, in fact, could develop rapidly enough to be the cause of serious complaint and still remain resistant to such concentrations of copper as could be safely used. At the worst the presence of these forms is certainly to be preferred to that of organisms producing odor and taste, and fortunately experience has shown that the latter succumb so readily to the copper treatment that their destruction has offered no great difficulty.

ODOR AND TASTE DUE TO LARGE NUMBERS OF ALGÆ KILLED.

A certain proportion of the algæ killed by copper treatment floats to the surface and disintegrates there, but the greater part apparently sinks to the bottom, and it may sometimes be necessary to flush out this lower stratum of water and decaying organic matter. In case large masses accumulate upon the surface, as may occur in a reservoir very badly infested with Anabaena, it is desirable to skim off as much of this mass as possible. By this means the water can be rendered fit for use in the minimum length of time, although such procedure would be required only in a reservoir in which the polluting algæ had developed until the water was in very bad condition, and this should never be allowed to happen. The algologist of a water company should watch for the appearance of polluting forms, and advise treatment as soon as signs of increase are unmistakable.

The only undesirable effect of treating a water supply which is contaminated with an alga producing odor and taste is that during the first few days after treatment the odor and taste may increase. In a municipal supply in which the service mains are fed from the bottom of the reservoir this increase may be very marked and occasion additional complaint among the consumers. The trouble is, of course, caused by the simultaneous disintegration of large numbers of algæ and the consequent liberation of comparatively large quantities of the volatile oils to which the odor and taste are due.

NECESSITY FOR DETERMINING THE POLLUTING ORGANISM.

Before the quantity of copper required in a particular reservoir can possibly be determined it is absolutely necessary to ascertain the exact character of the organism causing the trouble. This makes a microscopical examination of the first importance. Also, the earlier in its development the presence of the polluting form is revealed, the more effective will be the treatment. If examinations are made at short intervals throughout the year, the first appearance of the troublesome algæ can be noted, and by treating promptly at the first sign of their decided increase it is possible to destroy them before the consumer is caused any annoyance. This makes a considerable difference in the expense of treatment also, as it may require fifteen to twenty times as much copper to clean a reservoir after the bad taste and odor are evident as it would if the application had been made before the organism had established itself.

In all cases the use of copper is advocated as a preventive rather than as a cure, and the treatment can not be intelligently applied unless the microscopical examinations are thorough and frequent at the time of year the trouble is to be expected.

TROUBLESOME FORMS AND THEIR IDENTIFICATION.

The bad odors and tastes due to the presence of algæ may be due either to a definite secretion from the plant or to its decomposition. In most water supplies the difficulty is first evident before the algæ have begun to die, and, although the objectionable conditions may be augmented by subsequent decay, there are comparatively few alga-infested reservoirs in which the disagreeable effect is not originally produced by the living algæ. The effects directly produced by these plants have been so variously described that it is difficult to arrange any classification which will enable one to identify the organism by the odor or taste produced. In general, however, it may be said that the diatoms cause what has been termed an "aromatic" odor, although if in great quantity it is apt to be nauseating and fishy. Uroglena, which in this country usually appears during the winter months, is the form causing the most characteristic fishy taste and odor. Volvox is reported to have a similar effect. There are also certain forms closely related to both Uroglena and Volvox which at times may produce a flavor suggestive of fish.

During the summer by far the greatest difficulty in water supplies infested with algæ is due to the blue-greens, or Schizophyceae. The odor first noticeable has been described as grassy or moldy, but this usually changes as decay sets in to a pronounced "pig-pen" odor, which can frequently be detected for a considerable distance from the reservoir. Many of the larger grass-green algæ, such as Cladophora, Conferva, Spirogyra, Hydrodictyon, etc., cause trouble by being present in such quantities as to produce a distinct vegetable odor when they begin to disintegrate.

(To be concluded.)

* Abstracted from Bulletin No. 76 of the Bureau of Plant Industry, Department of Agriculture.

[1] Bulletin 64, Bureau of Plant Industry.

[2] At Coldspring Harbor, N. Y., through the courtesy of the Bureau of Fisheries and the New York Forest, Fish, and Game Commission.

[3] In water containing carbonates, if the amount of dissolved carbon dioxid is very low, the basic carbonate of copper formed may be considered insoluble; if, however, the water should contain a fair amount of carbon it would bring the copper carbonate at least partially into solution. In general, it will be safe to treat a lake with a concentration beyond that which the fish in it could endure in pure water, and the concentration may increase with the quantity of organic matter present.

[4] Report of the Commission of Fish and Fisheries, Part XXVII, p. 118, 1901.

THE VARIABILITY OF MODERN AND ANCIENT PEOPLES.*

IT has been generally supposed that modern peoples deviate more widely than ancient peoples from their respective means. The writer's investigations upon the Egyptian fellahin, however, lend no support to this supposition, alike in length, breadth, and horizontal circumference of head and in cephalic index. The variability of the modern population of Kena and the neighboring district is not sensibly different from that of inhabitants of the same region six or seven thousand years ago, as deduced by Miss Fawcett and others from the Nakada collection. So, too, the variability in cephalic index of ancient Bavarian skulls is found to be almost identical with that of the modern Bavarian population; and the variability of the cephalic index in modern French and English does not exceed, but is probably less than that in ancient Gaulish and British skulls respectively.

More evidence is urgently needed, but what little we have supports the contrary hypothesis that modern and ancient populations living under like conditions of

* Abstract of paper read before Section H of the British Association meeting at Cambridge, by C. S. Myers, M.D.

country and climate differ little in variability. Prof. Karl Pearson, on the other hand, supposing that a diminishing struggle for existence encourages the persistence of individuals showing greater variability, believes that variability increases with increasing civilization. The opposite view, however, appears tenable, that stringent selection encourages greater variability. It explains why in several features the oppressed Copts show greater variability than the Mohammedan population of Egypt, and the Whitechapel series of skulls of the sixteenth century is more variable than the general upper middle and upper class population of modern England. The more prosperous community tends to homogeneity; in other words, to regression toward its mean.

CONTEMPORARY ELECTRICAL SCIENCE.*

SEXTANT ELECTROMETER.—M. Guinchant has devised an electrometer in which the needle is charged by induction, and is suspended by an insulating fiber instead of a conducting one. The directing couple is given by a bifilar suspension or a small magnet. There are six sectors, placed in the same plane under the needle. The latter is a plate of silvered mica strengthened with strips of mica. Two of the sectors are larger than the others, and form a kind of figure of eight, filling an angle of some 80 deg. on each side of the center. The other sectors are smaller and further away. The needle in its normal position covers the whole of the central sectors and about a third of the outer ones. The theory of the instrument is the same as that of the quadrant electrometer. An outer sector, the needle and half a central sector may be considered as forming a system of two condensers in cascade. The author expects to get a deviation of 1 millimeter per millivolt, on a scale at 1 meter.—Guinchant, Comptes Rendus, March 27, 1905.

RADIUM FROM FANGO MUD.—Though the activity of fango and Capri earth is only about one-thousandth of that of pitchblende, the process by which radium is obtained from uranium ores can be successfully applied to it, owing to the insolubility of the radium-barium sulphate and its property of precipitating the radio-active earths with itself. Sixty kilogrammes of moist fango, analyzed by F. Giesel, gave 0.39 gramme of barium carbonate and 0.05 gramme of an ammonia precipitate. Both preparations excited the barium platinocyanide screen, and have remained active for half a year, thus showing the presence of radium. Forty kilogrammes of Capri earth were subjected to three extractions by means of hydrochloric acid, which could be employed owing to the total absence of sulphuric acid. The third extraction, taken with excess of acid, gave 0.15 gramme barium carbonate with an initial activity of 33,000 volts, and a final activity of 192,000 volts after three weeks. The most insoluble fraction showed distinct self-luminescence. No uranium was found in either of the earths examined.—F. Giesel, Physikalische Zeitschrift, April 1, 1905.

EFFECT OF ULTRA-VIOLET LIGHT ON GLASS.—F. Fischer has examined the effect produced on various glasses by ultra-violet light from a quartz-mercury arc lamp. The glass was placed very near the quartz wall. The intervening space was sometimes filled with hydrogen, but without producing any difference. The results were not produced by Röntgen or cathode rays. Out of eight glasses examined, four showed a change of color within a quarter of an hour, which developed into a deep violet in 12 hours. The coloration was found to be connected with the presence of manganese, as in Schott's thermometer glass and ordinary Thuringian glass. The substance producing the color is manganous silicate. The author recalls Sir William Crookes's recent announcement that certain kinds of glass were found to acquire a violet color on prolonged exposure to sunlight at Uyni, Bolivia, a place situated 4,000 meters above sea level. At this altitude, sunlight contains a considerable proportion of ultra-violet rays. The author suggests that the permanent coloration of tubes under the influence of Röntgen rays and radium rays may be due to a secondary generation of rays of short wave length.—F. Fischer, Physikalische Zeitschrift, April 1, 1905.

FRICTIONAL EXCITEMENT OF VACUUM TUBES.—C. Hess describes a curious phenomenon which appears to offer a method of converting friction direct into light of a very economical kind. He was experimenting with an electrodeless tube held in the hand and connected with one terminal of a Holtz machine, while the other end of the tube faced the second terminal of the machine. The tube thus represented a kind of Kleist jar, and on touching the free end with the free hand a shock was felt and a luminous discharge passed through the tube. This might have been expected, but the author also found that subsequently the tube could be brought to flash up by simply rubbing the hand over it. He then examined a number of vacuum vessels of all kinds, including glass spheres, Geissler tubes containing oxygen, hydrogen, nitrogen, carbonic oxide and acid, argon and helium, as well as glow lamps of various makes, and finally the Torricellian vacuum. In every case, the vessel could be brought to shine out by friction only, though the first incandescence was sometimes slow in coming. At lower exhaustions, the light consists of a cloud which follows the hand, while at higher vacua a ring of light adheres to the walls and moves with the finger, or a little more slowly. Hydrogen tubes are extremely sensitive, and may be brought to shine out by means of a fine brush. The author supposes that the gas is ionized by the first friction, and is thereafter capable of discharging subsequent charges, the electrons proceeding from the walls and colliding with the positive ions at distances varying with the pressure.—C. Hess, Physikalische Zeitschrift, April 1, 1905.

* Compiled by E. E. Fournier d'Albe in the Electrician.

SCIENCE NOTES.

The small marbled cats known as ocelots (*Felis pardalis*) have hitherto been regarded as an exclusively New World type, where they are most abundant in Central and South America. Re-examination of the Central Asiatic species known as *Felis tristis*, according to Knowledge, has led the present writer to believe that it is an Old World representative of the ocelots. If this view be correct, it will serve to show that the ocelots (as has always been supposed to be the case) originally entered America by way of Bering Strait. It is also urged that the clouded leopard (*F. nebulosa*) and the marbled cat (*F. marmorata*) of the Indo-Malay countries are also members of the ocelot group, but of a more aberrant type.

It is generally understood that insects, like other "cold-blooded" creatures, have no temperature of their own, but put themselves in equilibrium with that of the surrounding medium, air or water. M. Acloque summarizing in Cosmos recent investigations on this subject, suggests, however, that there are several experiments to show that the generalization is not true in all cases, and that there are reasons for supposing that insects produce heat. A Fahrenheit thermometer was found by Inch to rise seven degrees in an ant-hill, and Swammerdam and Réaumur observed that the temperature of beehives keeps above that of the external air in winter. According to Huber, who repeated these observations, this temperature is nearly constant at 88 deg. Fahrenheit. Réaumur added that when the bees were agitated they caused their wings to vibrate with great rapidity, and the interior heat then increased to such a point that the walls became warm, and sometimes even the wax melted. However this may be, we may say that the heat given off individually by insects is always very slight. By way of compensation, they confirm the general law according to which living creatures resist cold better as their ability to give off heat is slighter. Caterpillars do not necessarily die when turned into bits of ice; and this resistance to cold explains why we can find insects in regions very near the Pole, and why the rigors of our own winters do them so little injury. Certain species, and in particular some lepidoptera, hatch out only in winter, which explains again, perhaps, how it is that some flowers like the yellow Cape jessamine, now blooming in Surrey, can become fertilized in winter. Insects bear heat as well as cold, and Kirby and Spence have affirmed that some can survive immersion in boiling water.

Some time ago Prof. A. B. Meyer, the Director of the Zoological Museum at Dresden, published an article on the alleged existence of the lion in historical times in Greece. A translation of this article appears in the recently issued Annual Report of the Smithsonian Institution. As regards the mention of that animal in Homer, the author is of opinion that the writer of the Iliad was probably acquainted with the lion, but this does not prove its former existence in Greece. The accounts given by Herodotus and Aristotle merely go to show that about 500 B. C. lions existed in some part of Eastern Europe. The Greek name for the lion is very ancient, and this suggests, although by no means demonstrates, that it refers to an animal indigenous to the country. Although fossil bones of the lion have been recorded, no recent remains of that animal are known from Greece; but this cannot be regarded as a matter of any importance in connection with the question. On the whole, although the evidence is not decisive, it seems probable that lions did exist in Greece at the time of Herodotus; and it is quite possible that the representation of a lion-chase incised on a Mycenean dagger may have been taken from life. In prehistoric times the lion was spread over the greater part of Europe; and if, as is very probable, the so-called *Felis atrox* be inseparable, its range also included the greater part of North America. It may be mentioned that the journal above mentioned also contains a translation of an article giving an account of the discovery of the mammoth carcass recently set up in the St. Petersburg Museum. In publishing translations of articles of such general interest as the above, the Smithsonian Institution is doing good service to science, for although many of us have a more or less intimate acquaintance with German, it is but few who can read Russian or Norwegian.

The majority of modern marsupials, it has been stated, exhibit in the structure of their feet traces of the former opposability of the thumb and great toe to the other digits; and it has accordingly been urged that all marsupials are descended from arboreal ancestors. This doctrine is now receiving widespread acceptation among anatomical naturalists, and in a recent issue of the American Naturalist, Dr. W. D. Matthew, a well-known trans-Atlantic palæontologist, considers himself provisionally justified in so extending it as to include all mammals. That is to say, he believes that, with the exception of the duckbill and the echidna, the mammalian class as a whole can lay claim to descent from small arboreal forms. This conclusion is, of course, almost entirely based upon palæontological considerations; and these, in the author's opinion, admit of our coming to the conclusion that all modern placental and marsupial mammals are descended from a common ancestral stock, of which the members were small in bodily size. To follow Dr. Matthew in his hypothetical reconstruction of these ancestral mammals would obviously be out of place on the present occasion; and it must suffice to say that, in addition to their small size, they were characterized by the presence of five toes to each foot, of which the first was more or less completely opposable to the other four. The evidence in favor of this primitive opposability is considerable. In all the groups which are at present arboreal, the palæontological evidence goes to show that their ancestors were likewise so; while, in the case of modern terrestrial forms, the structure of the wrist and ankle joints tends to approximate to the arboreal type as we recede in time. The available evidence, so far as it goes, is therefore decidedly in favor of Dr. Matthew's contention. The author next discusses the proposition from another standpoint—namely, the condition of the earth's surface in Cretaceous times. His theory is that in the early Cretaceous epoch the animals of the world were mostly aerial, amphibious, aquatic, or arboreal, the flora of the land being undeveloped as compared with its present state. On the other hand, toward the close of the Cretaceous epoch (when the chalk was in course of deposition), the spread of a great upland flora vastly extended the territory available for mammalian life. Accordingly, it was at this epoch that the small ancestral insectivorous mammals first forsook their arboreal habitat to try a life on the open plains, where their descendants developed on the one hand into the carnivorous and other groups in which the toes are armed with nails or claws, and on the other into the hoofed group, inclusive of such monsters as the elephant and giraffe.

TRADE NOTES AND RECIPES.

Furniture-cleaning Polish.—Melt 4 parts of yellow wax and 1 part rosin, and add 15 parts oil turpentine. Color the mass with ocher or umber. Place a little of this mixture on a woolen rag, and rub the furniture with it.—Farben Zeitung.

Paste for Razor Strops.—Melt 1 part of white wax, ½ part of rosin, ½ part of thick turpentine, 2 parts of white soap, and 2 parts of olive oil in an iron enameled pot, and add to this molten mass 1 part of English red, 5 parts of emery, 2 parts of bloodstone, 4½ parts of graphite, all finely powdered and levigated. Stir until the paste commences to thicken, when it should be filled in small tins.—Drogist. Rundschau, Zurich.

Exposition of Milan.—The regulations of this exposition, which was to have been held the present year, but which has been deferred to 1906, have been modified to meet this change, and in some other particulars. The principal provisions are now the following:

Applications for space must reach the executive committee before May 31, 1905. Objects accepted must be consigned, with their certificates of admission, by February 1, 1906. Machinery and heavy and bulky merchandise, necessitating the employment of motive force and the construction of foundations, must be consigned before December 1, 1905. Applicants whose productions are not installed by February 28, 1906, will lose their rights of exhibition.

Turkish trade with foreign countries has experienced an unwonted tendency. European exporters, who have long been accustomed to lower prices and the quality of their commodities to correspond, find that they must reverse their tactics. The Handels Museum of Vienna relates the experience of the Italian merchants, who competed for many years successfully in consigning merchandise cheap both in price and quality. But the Turkish dealers, who are good judges of merchandise, and who had accepted certain Italian goods from the fine appearance with which they were decked, came to realize that they had paid enough for good looks; they gave the cold shoulder to Italian productions of all kinds. Now exporters must raise the quality of their commodities, and calculate their profits more closely.

Water Power on the Upper Rhine.—The fall of the water between Waldshut and Mannheim is 200 meters, the greater part between Basle, where the descent is one meter per kilometer, and Mannheim, where it is one meter for ten kilometers. When the Rheinfelden factory was erected, numerous applications for the use of other waterfalls were made, and the population on the banks of the river became so interested that a financial syndicate undertook to acquire the control of all the falls. In a discussion in the representative assembly of the grand duchy of Baden, the question was raised whether the water power might not be used for public works, and later whether the State ought not to control the power and distribute it by sale to the factories, but the trend of opinion is in favor of granting concessions and leaving the whole management to private capital.

Coloring of Soldering Seams.—The soldered places of metallic articles may be given the color of the article itself by means of the following processes: For copper objects use a concentrated solution of blue vitriol, and apply a certain amount of it to the soldered places, using a thin rod. When this spot is touched with a wire of iron or steel, a copper deposit forms on it, the thickness of which may be increased by several repetitions of the process. The shade of brass is obtained by applying to the place previously coppered a solution consisting of one part of zinc vitriol and two parts of blue vitriol, and then rubbing a piece of zinc over it. This color may be darkened by sprinkling on gold powder and polishing subsequently. In the case of gold and gold-filled articles, the soldering

is first coppered; then apply a thin layer of gum or isinglass, sprinkle on powdered bronze, and rub energetically after the gum has dried, whereby a very brilliant polish is obtained. Next the article is gold-plated by means of a battery, thus producing a very uniform coloring. For objects of silver the following method is made use of: First, the soldered places are coppered as in the other cases, then they are rubbed with a brush dipped in silver powder. Smooth with the burnisher, and finally polish.—Allgemeine Uhrmacher Zeitung.

ENGINEERING NOTES.

Increase in the Speed of Vessels.—The press in Italy is much interested in a new method instituted by Prof. Carlo del Luigi, of the chair of physics of the Spezzia Lyceum, to increase the speed of vessels by the injection through openings of compressed air in the hold. It is believed that great acceleration may be achieved. The Italian Nautical Institute has expressed some doubts of the efficiency of the means employed; but experiments at Leghorn are said to prove that the advantage secured is considerable.

A novel system of combined ventilation and shop cleaning has been carried out at the new works of the Singer Manufacturing Company in Scotland by the J. M. Adam Company, pneumatic engineers, of Glasgow. This plant is installed in the woodworking department. There are eight cabinet-making workshops, 200 feet by 80 feet, containing specialized machine tools, and immediately from each tool the sawdust and chips are drawn as produced, and conveyed by air current to the main boilers, into the furnaces of which they are fed continuously and automatically for steam raising. The fans are motor-driven, and consist of nine equal units in three groups of three, concentrated in three main pressure ducts carried on a bridge of five spans, each of 50 feet in length, and about 30 feet high, supported on steel lattice columns across the yard between the factory and the boiler house. The bridge will also carry an elevated rope traction tramway, with a service of small trucks conveying to the same destination broken wood and other refuse too heavy for air-current transmission. The power absorbed will be approximately 150 B. H. P.

Mining has always been known as a dangerous occupation. Much of the labor underground and on the surface at a mine is done for the very purpose of insuring the safety of the men. At the same time an effort is made to extract the mineral with as little labor as possible, and this attempt to produce a maximum tonnage per man employed per day may tempt the manager to neglect to some extent the precautions required to make his mine absolutely safe. The larger number of accidents are due to falls of roof. This would not necessarily show, however, that the management should be required to make the mines safer in this regard, by more extensive support of the roof. In the vast majority of cases everything has been made as safe as the economic working of the deposit will allow. Such matters as timbering and the control of the roof are very well understood by the coal miner and it is difficult to make any suggestions of better methods for the support of the roof. Yet more accidents occur from falling of rock than from any other cause. Many of these fatalities from rock falls are found to be due to the miner's own carelessness, but it is part of his business to be on the alert for this prevalent danger. In the coal mines another source of danger is the explosion. It is not responsible for so many victims as the fall of rock, because it occurs less frequently. But, affecting a large number of men suddenly or without warning, an explosion is a most fatal danger and needs to be specially guarded against.—Mines and Minerals.

Box-car loaders are decidedly of western origin, as without exception they have been invented, manufactured, introduced, and perfected in the West. This does not seem strange when the railroad conditions of that section are compared with those of the East. In the latter section, the gondola and hopper cars constitute by far the greater portion of the freight cars owned by the railroads. Employed as they are in hauling a great variety of products, they frequently travel in one direction loaded with coal and return loaded with iron ore or some other commodity. In the West, gondola and hopper cars are very scarce, and freight is hauled almost exclusively in box cars. Grain and cattle are hauled east to the large grain and stock centers, and inasmuch as the railroads cannot afford to haul the cars back empty across one State after another, they are used for transporting coal on the return trip. Aside from the nature of the equipment owned by the railroads in the two sections, it is necessary to load coal for western shipment in box cars which can be closed and sealed in order to prevent theft. When coal travels such short distances as it generally does in the East, the loss of weight in transit is quite small; but in traveling such great distances as it does in the West, open cars are entirely impracticable, as the railroads do not hold themselves responsible for such losses. Besides, the eastern railroads will not allow their gondolas to go into the far West. These differences in local conditions account for the fact that the majority of the box-car loaders in this country are used in the States of Illinois, Indiana, Iowa, Missouri, and Colorado, while they are considerably more scarce in Ohio and West Virginia, and Pennsylvania boasts of only about 35 of the 350 or 400 in use in the country.

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